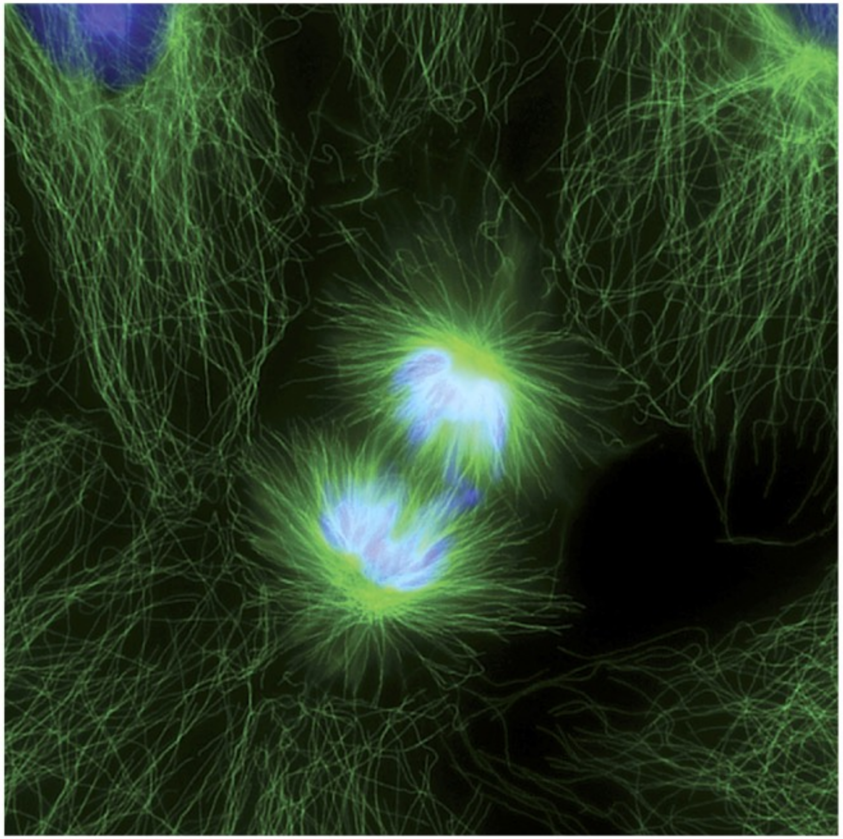
# BIOL2107, Fall ’23

# Lecture 10



Dr. Torsten Wittmann/Science Source

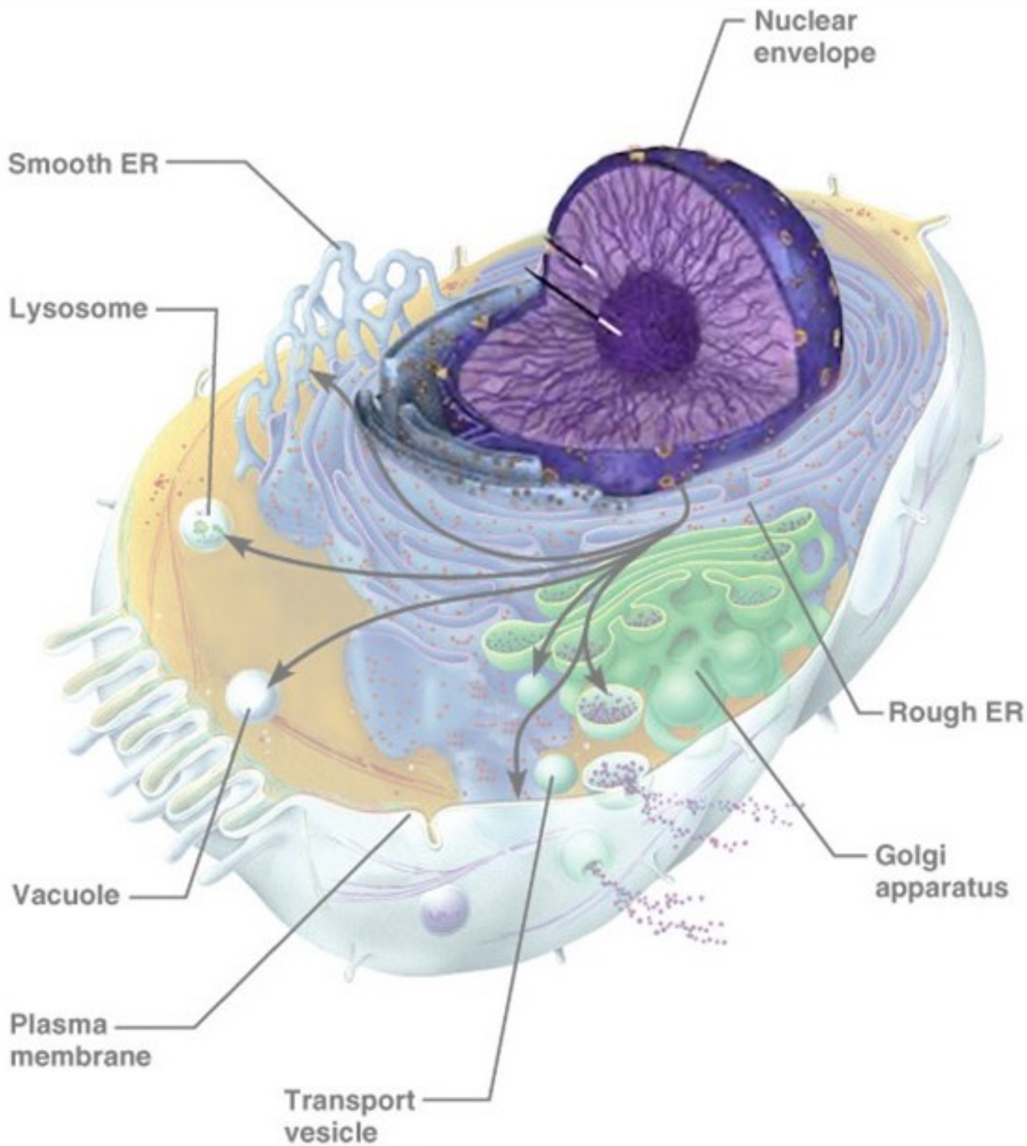
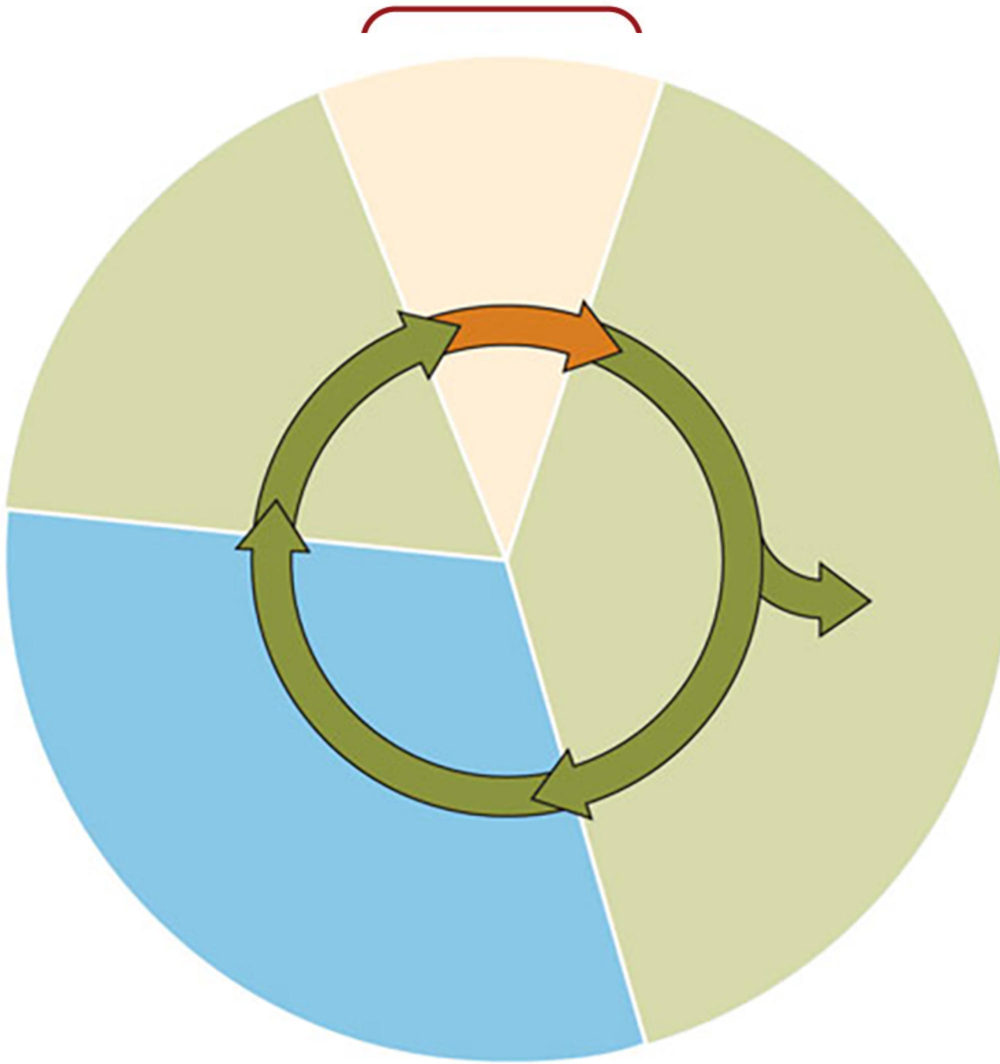
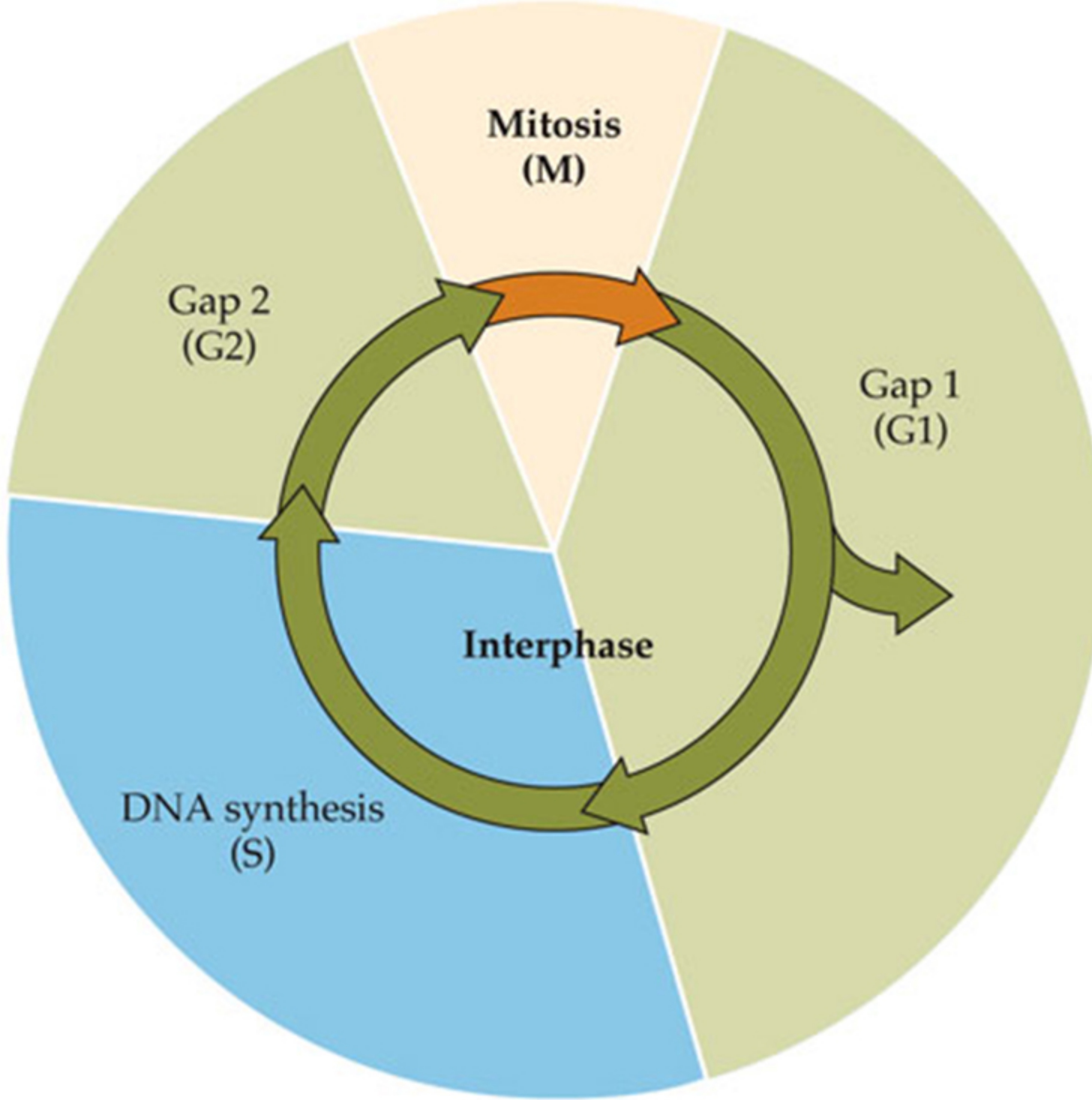
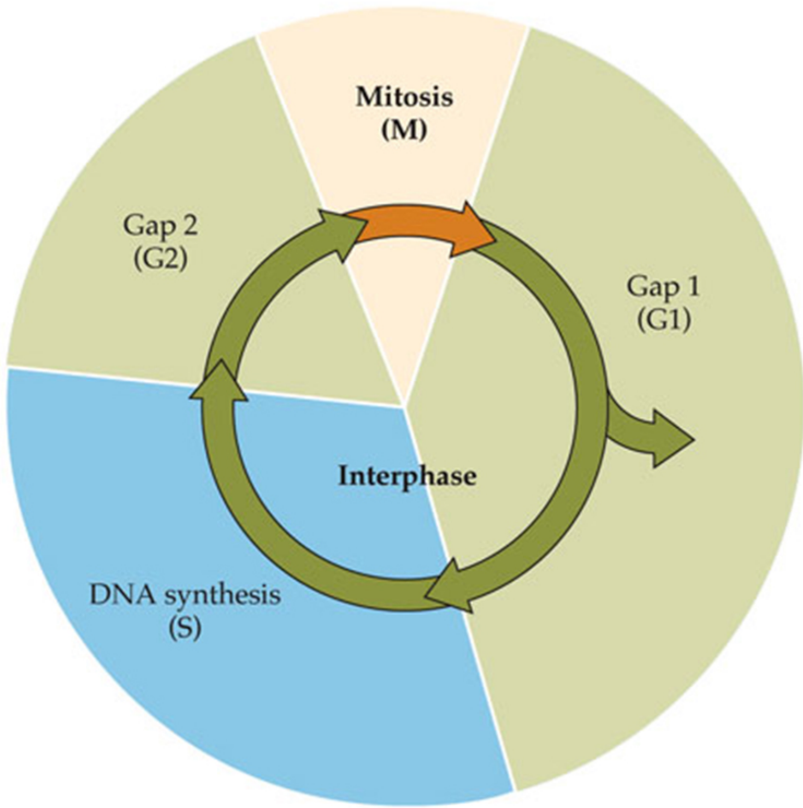
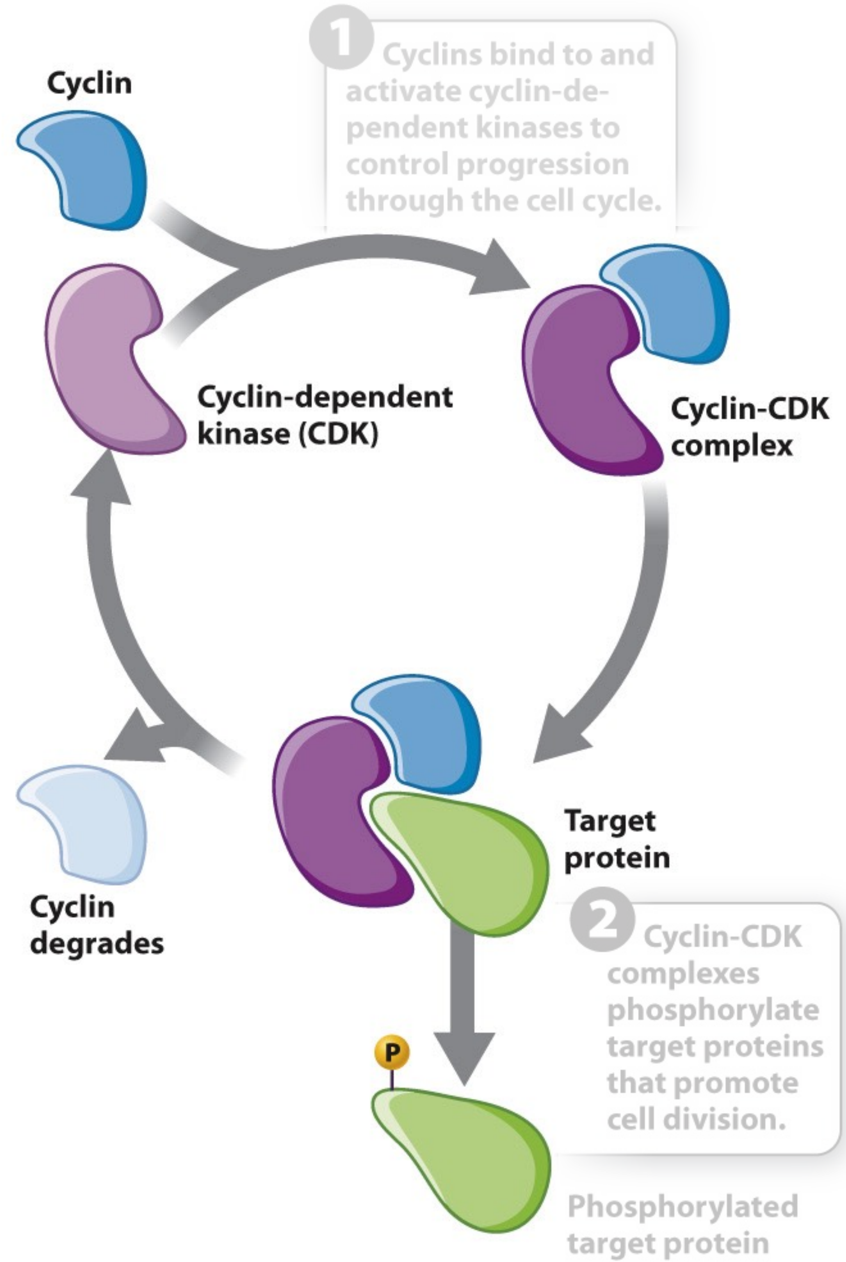

Nuclear envelope
Smooth ER
Lysosome
Rough ER
Golgi apparatus
Vacuole
Plasma membrane
Transport vesicle

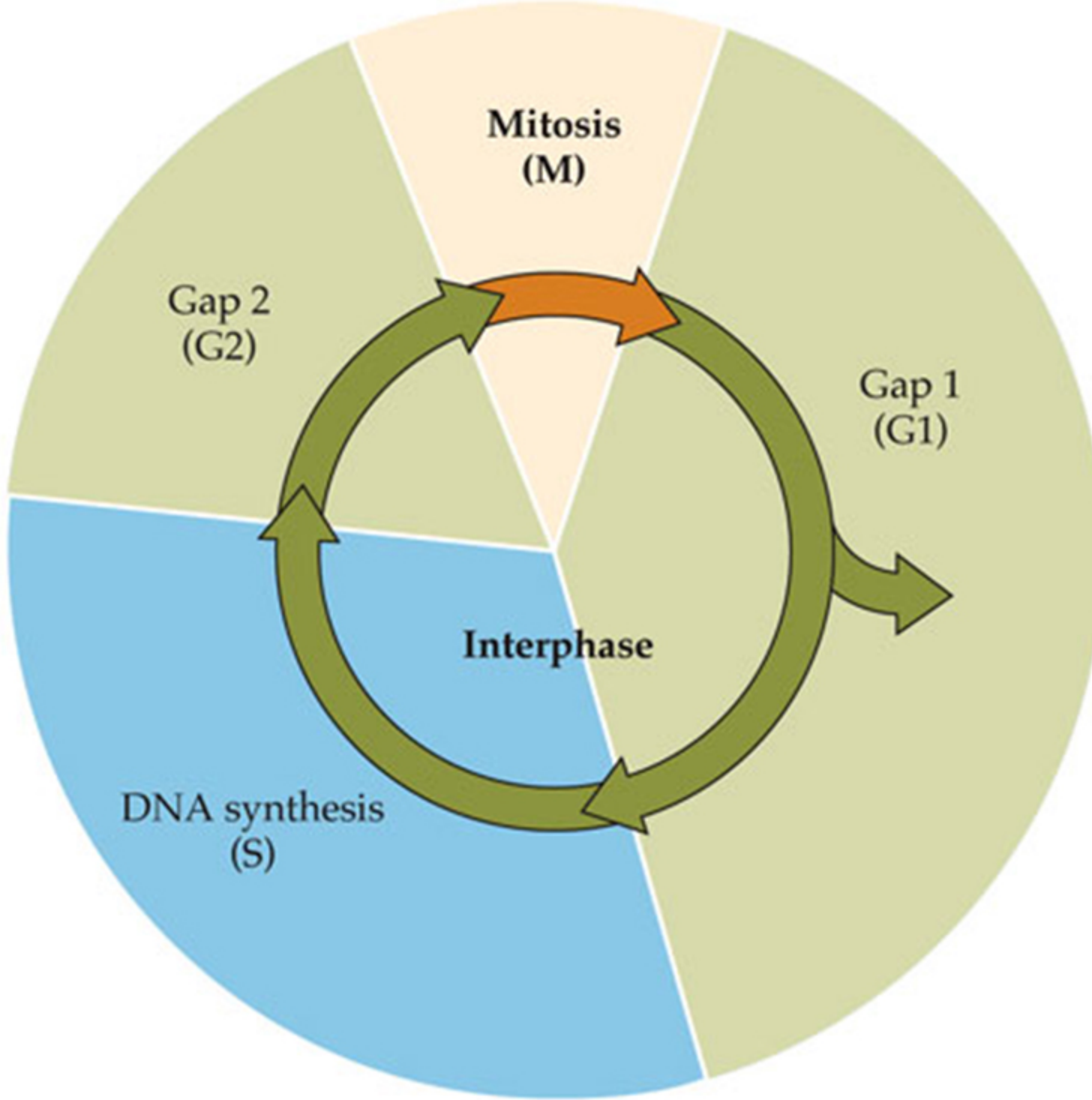
Figure 3.23

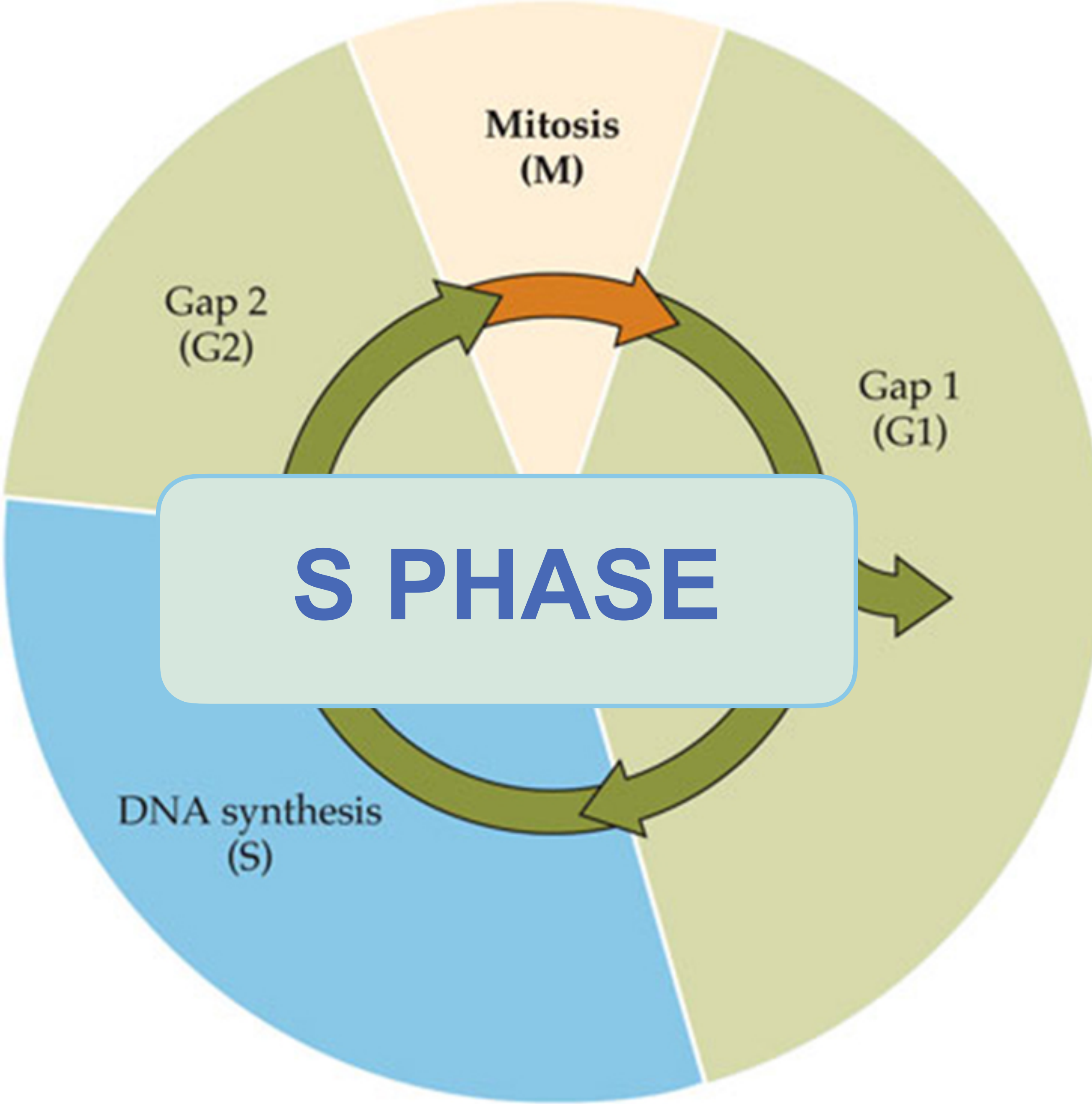



Mitosis
(M)
Gap 2
(G2)
Gap 1
(G1)
Interphase
DNA synthesis
(S)


Mitosis
(M)
Gap 2
(G2)
Gap 1
(G1)
Interphase
DNA synthesis
(S)


1 Cyclins bind to and activate cyclin-dependent kinases to control progression through the cell cycle.
Cyclin
Cyclin-dependent kinase (CDK)
Cyclin-CDK complex
Target protein
Cyclin degrades
2 Cyclin-CDK complexes phosphorylate target proteins that promote cell division.
P
Phosphorylated target protein


Mitosis
(M)
Gap 2
(G2)
Gap 1
(G1)
Interphase
DNA synthesis
(S)


Mitosis
(M)
Gap 2
(G2)
Gap 1
(G1)
S PHASE
DNA synthesis
(S)

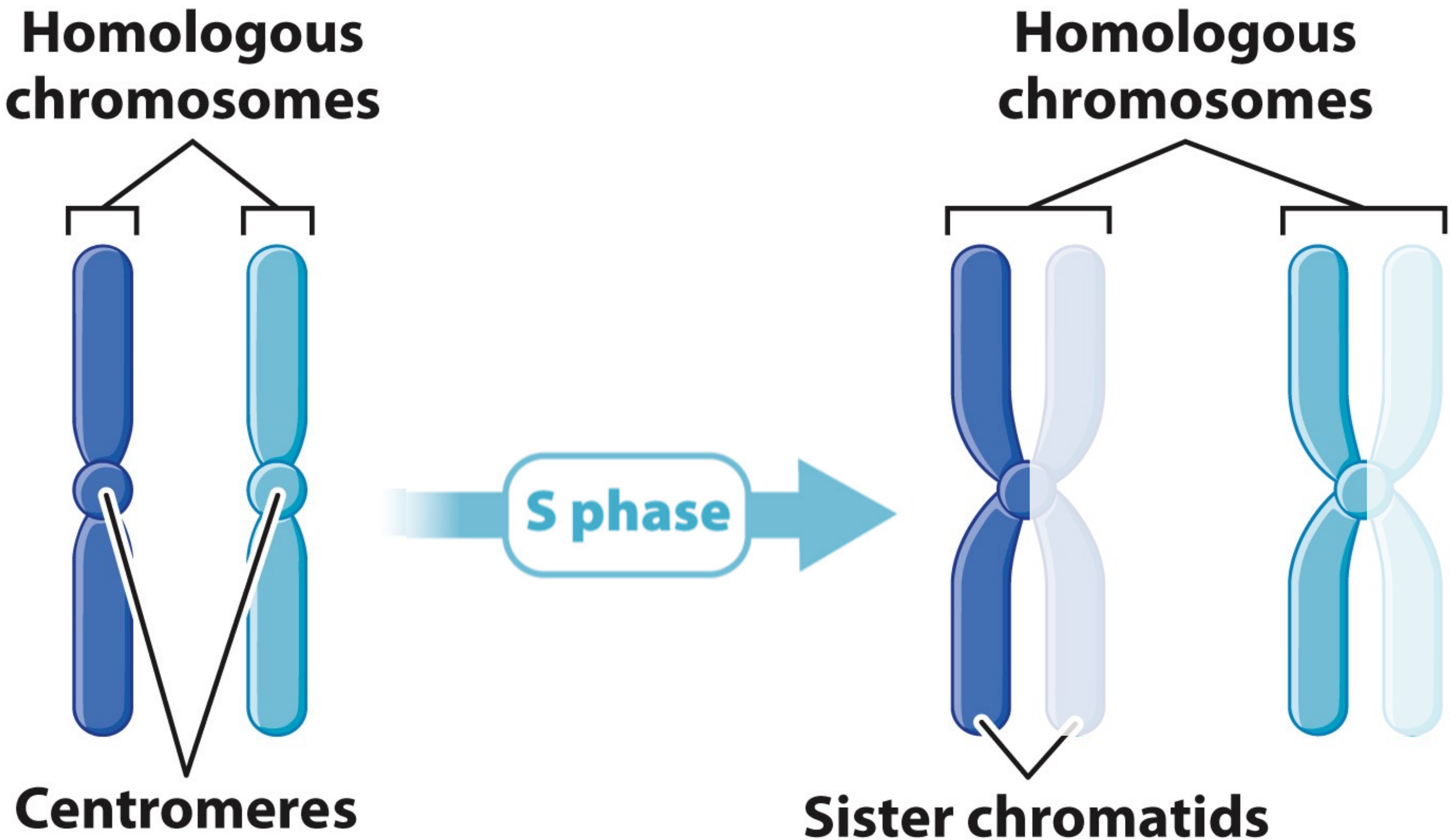
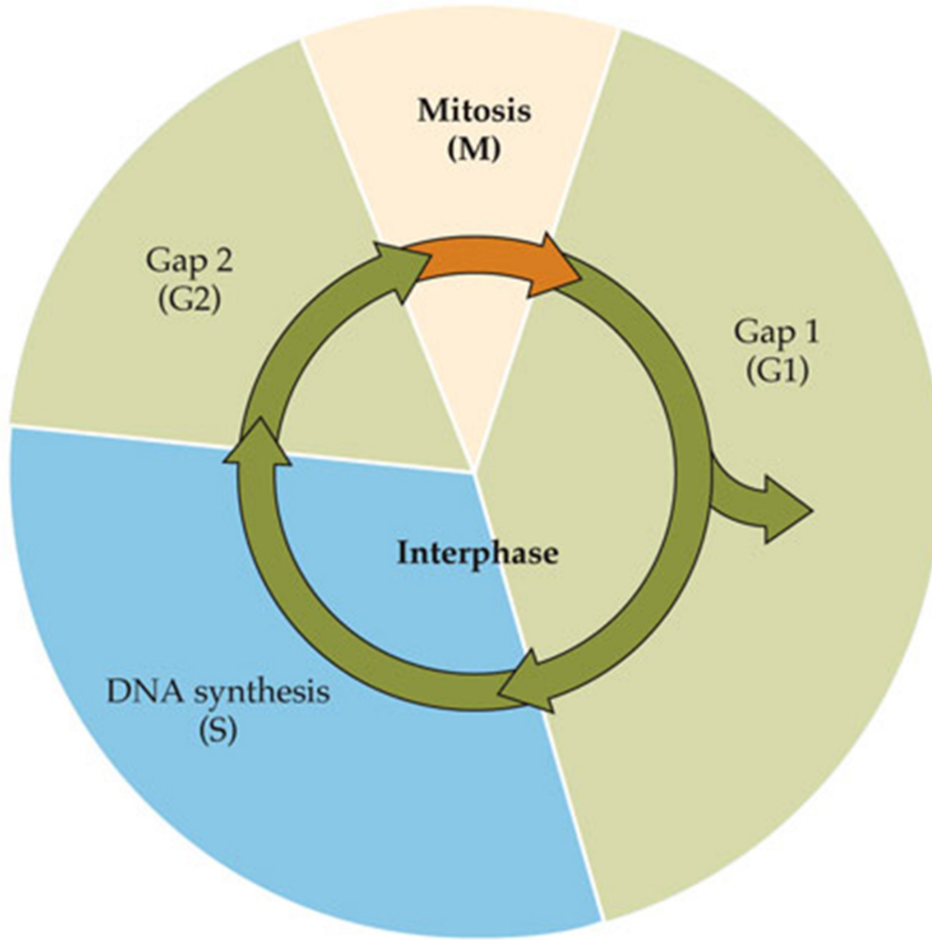
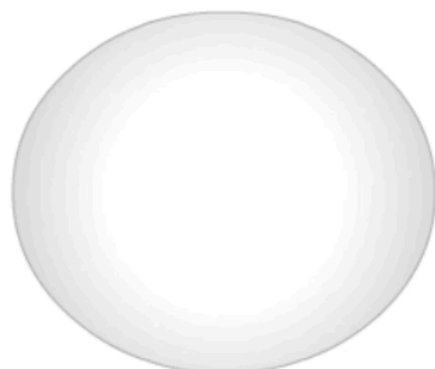



**Figure 11.4**
*Biology: How Life Works*, Second Edition


Mitosis
(M)
Gap 2
(G2)
Gap 1
(G1)
Interphase
DNA synthesis
(S)

# Mitotic Cell Division



In mitotic cell division, a single parent cell divides into two daughter cells.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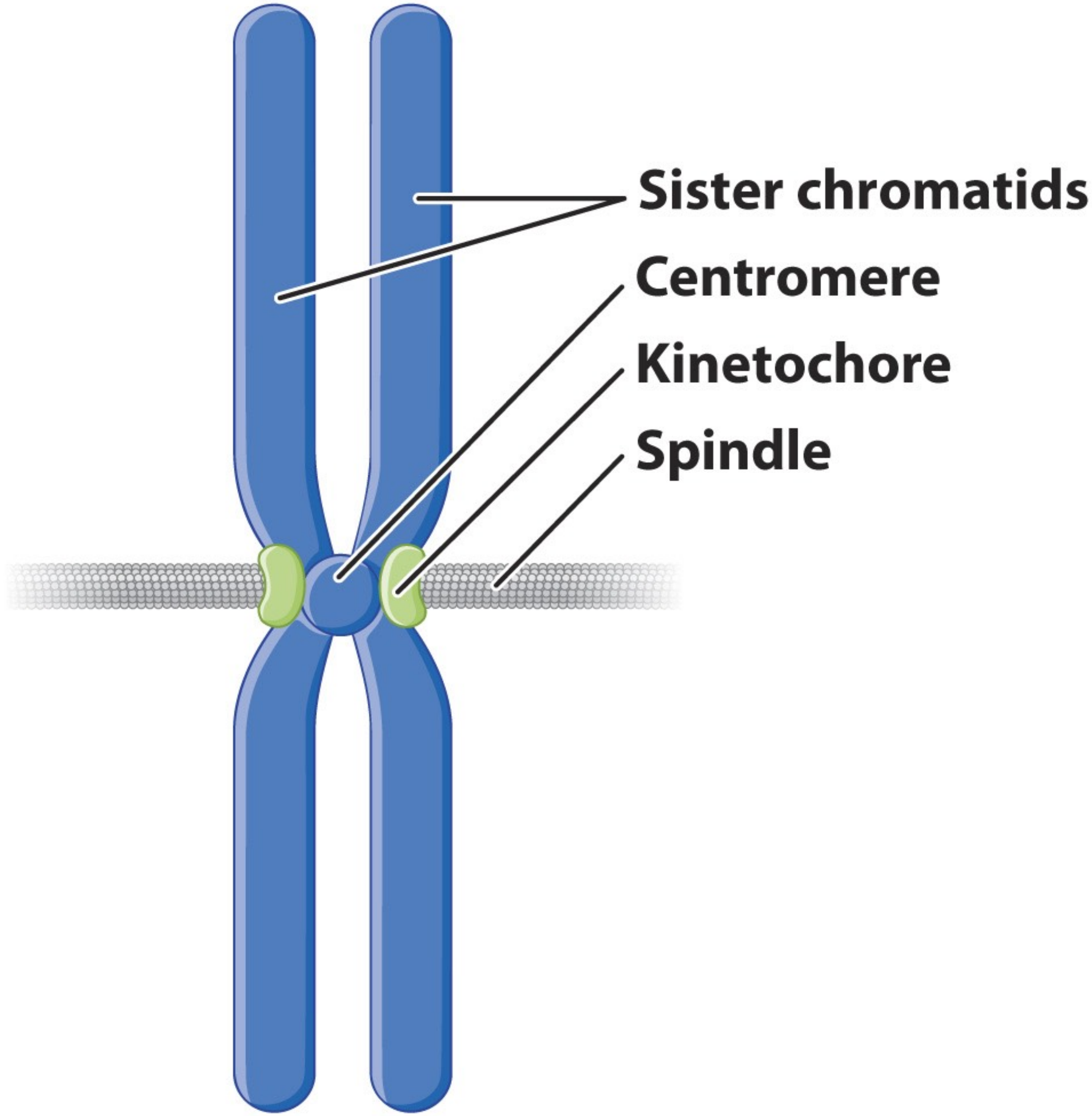
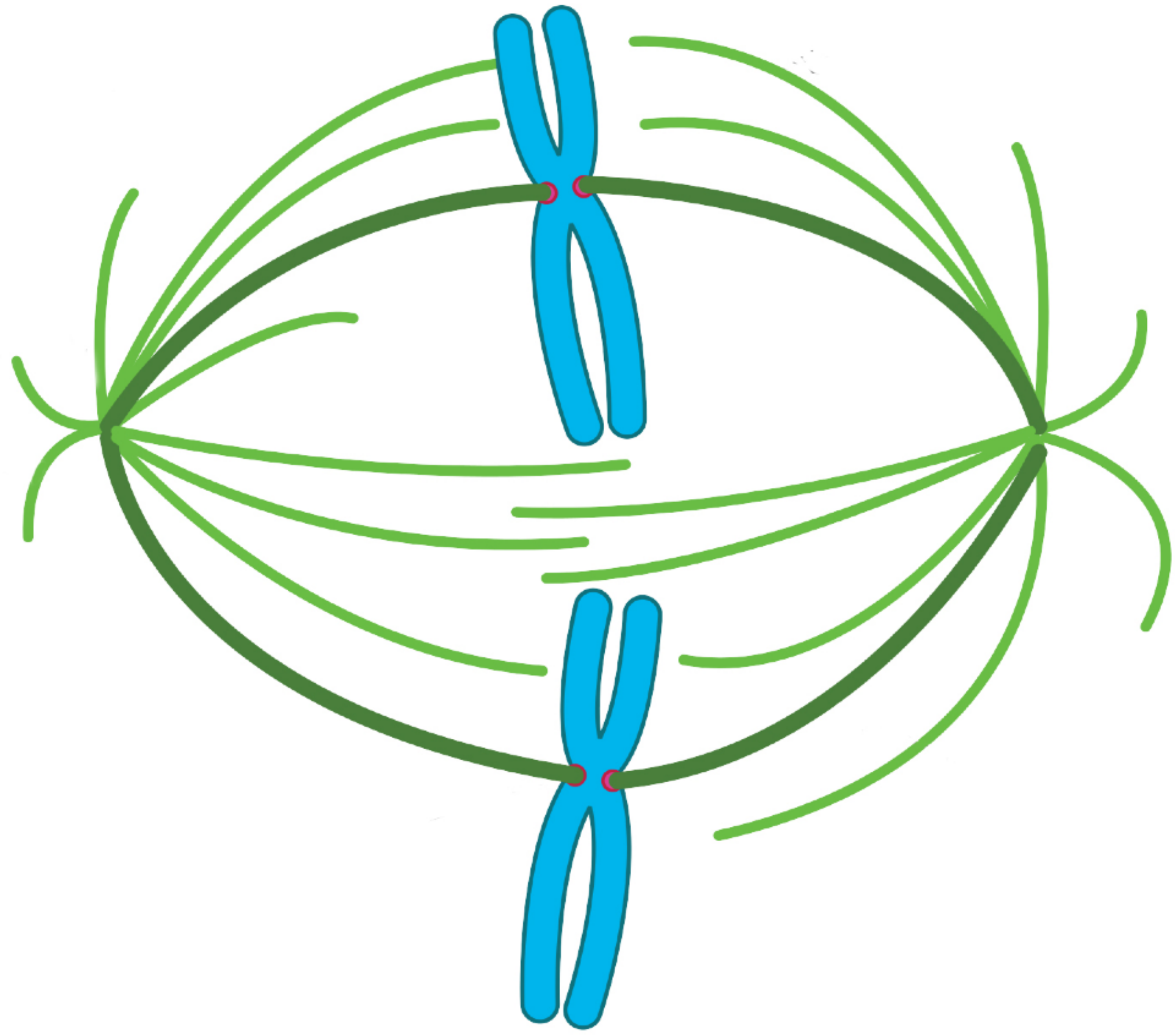
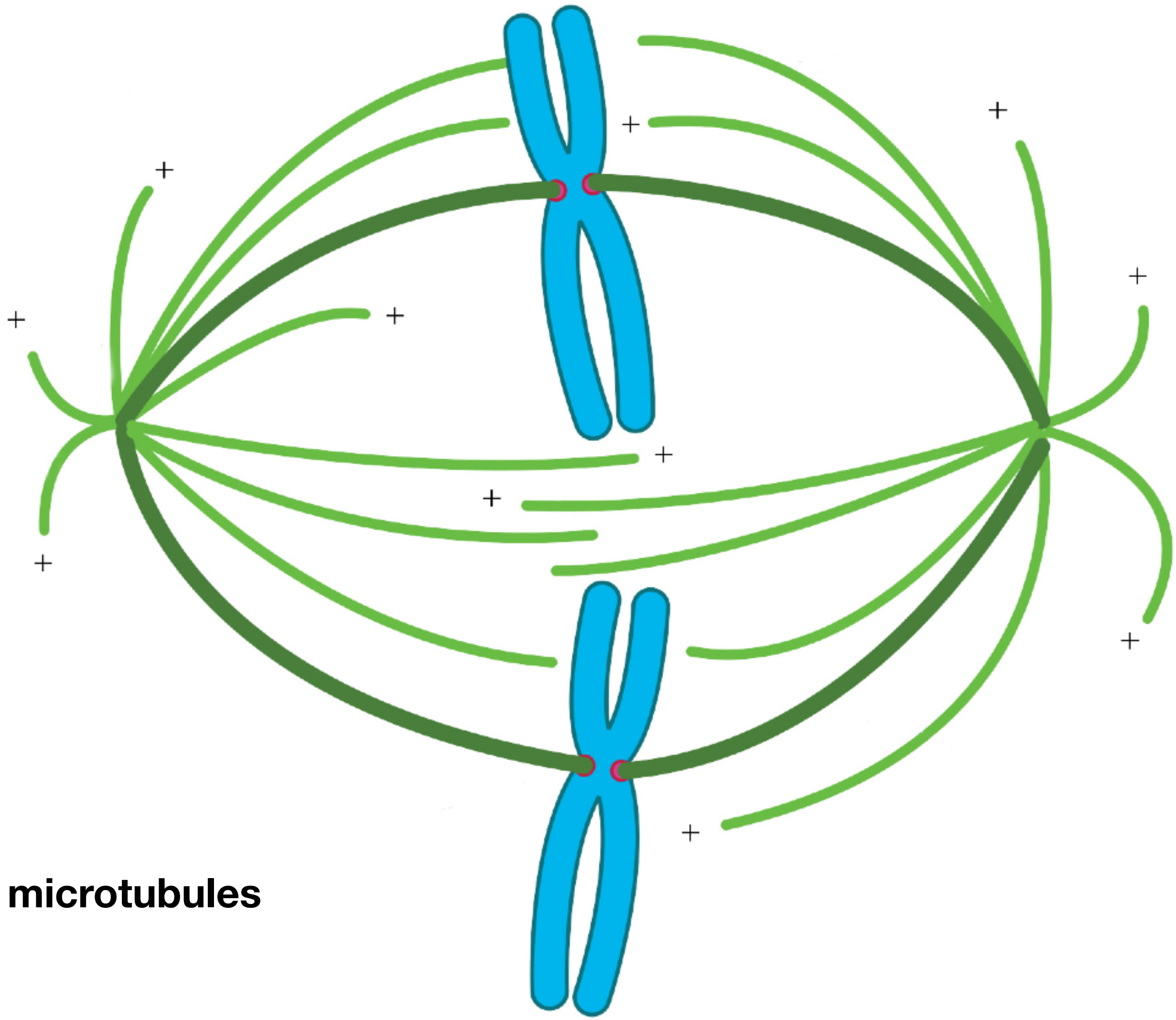
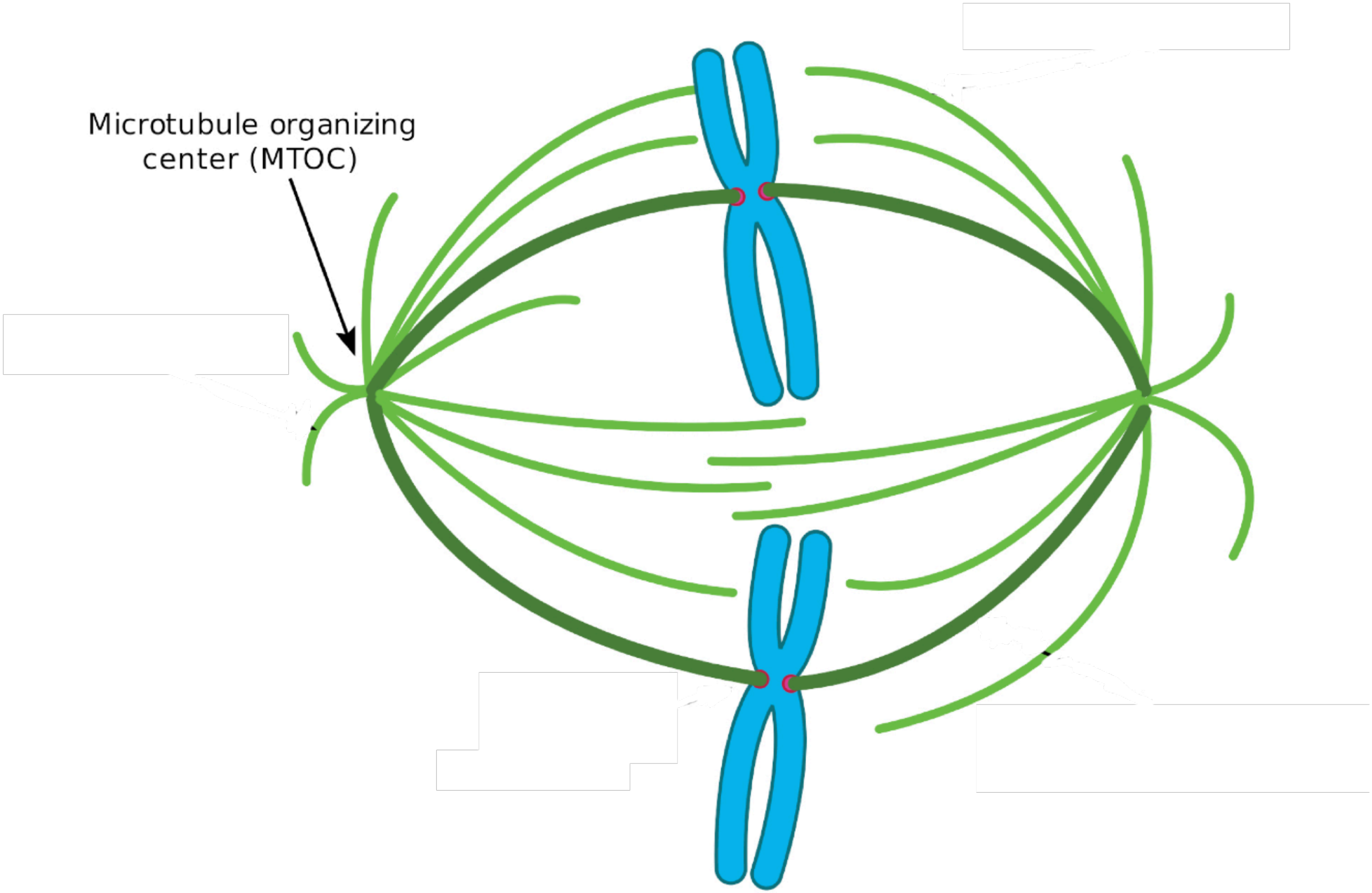


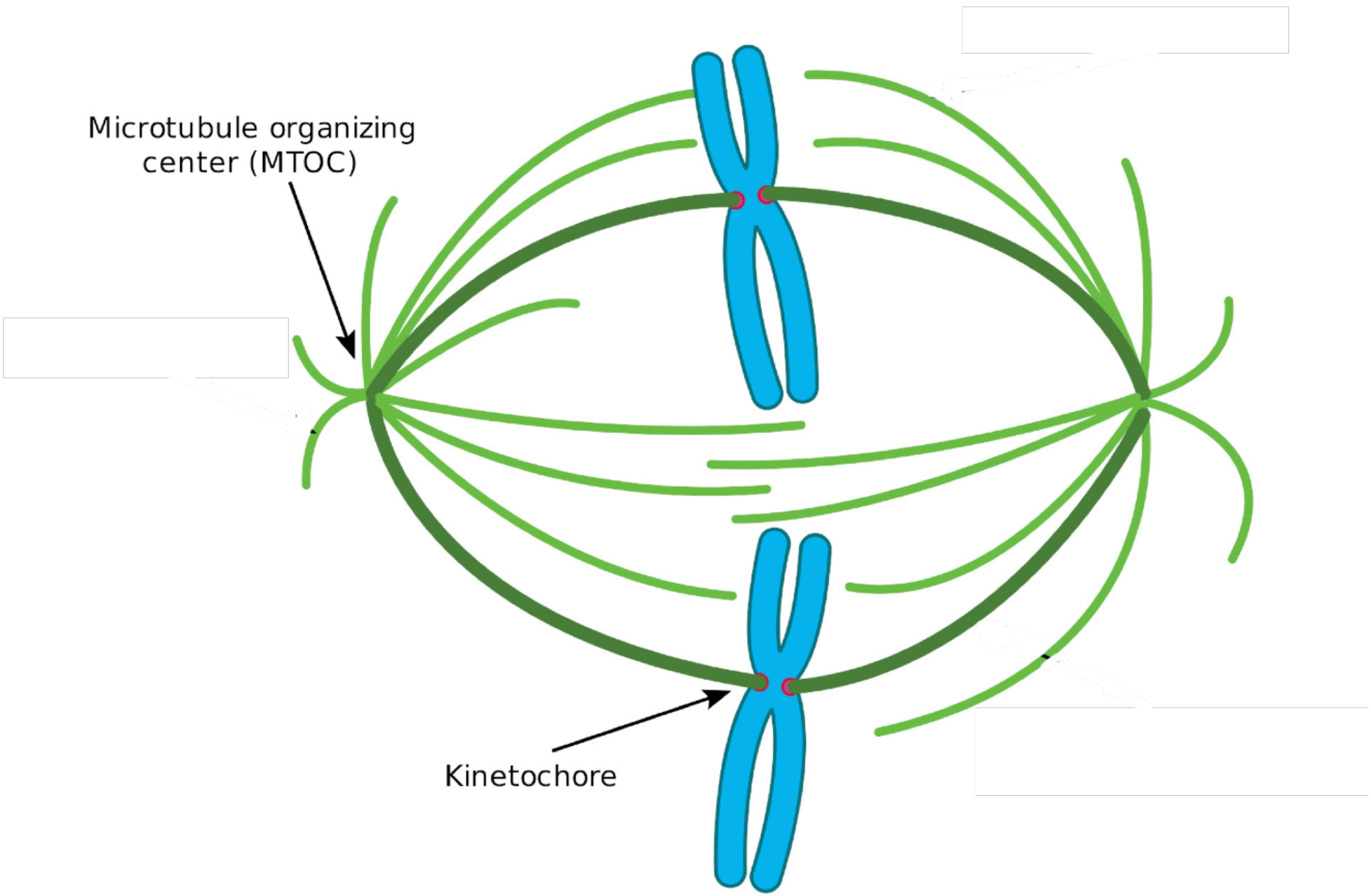

**Figure 11.6**
*Biology: How Life Works*, Second Edition



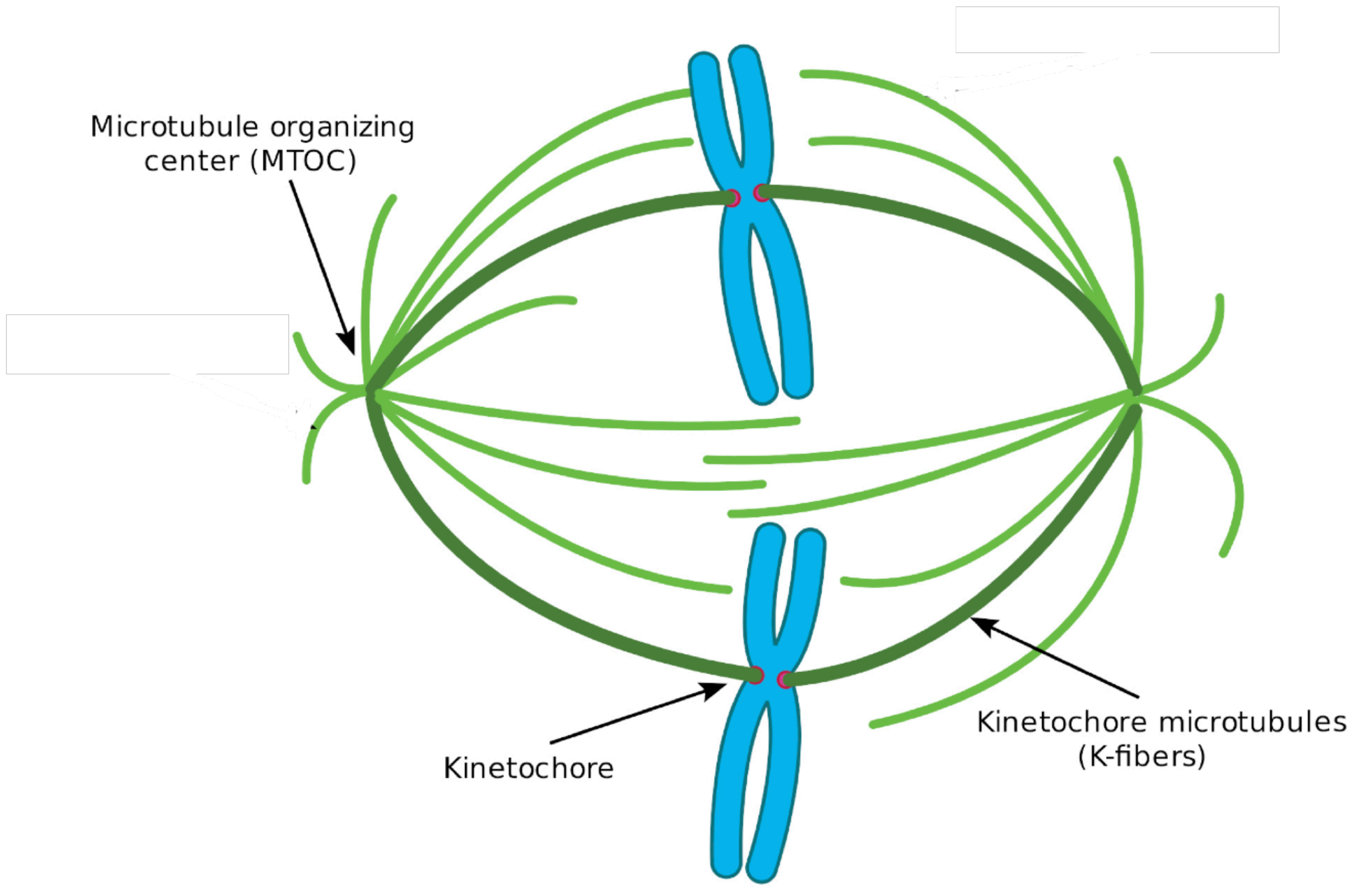



**3 different kinds of microtubules**

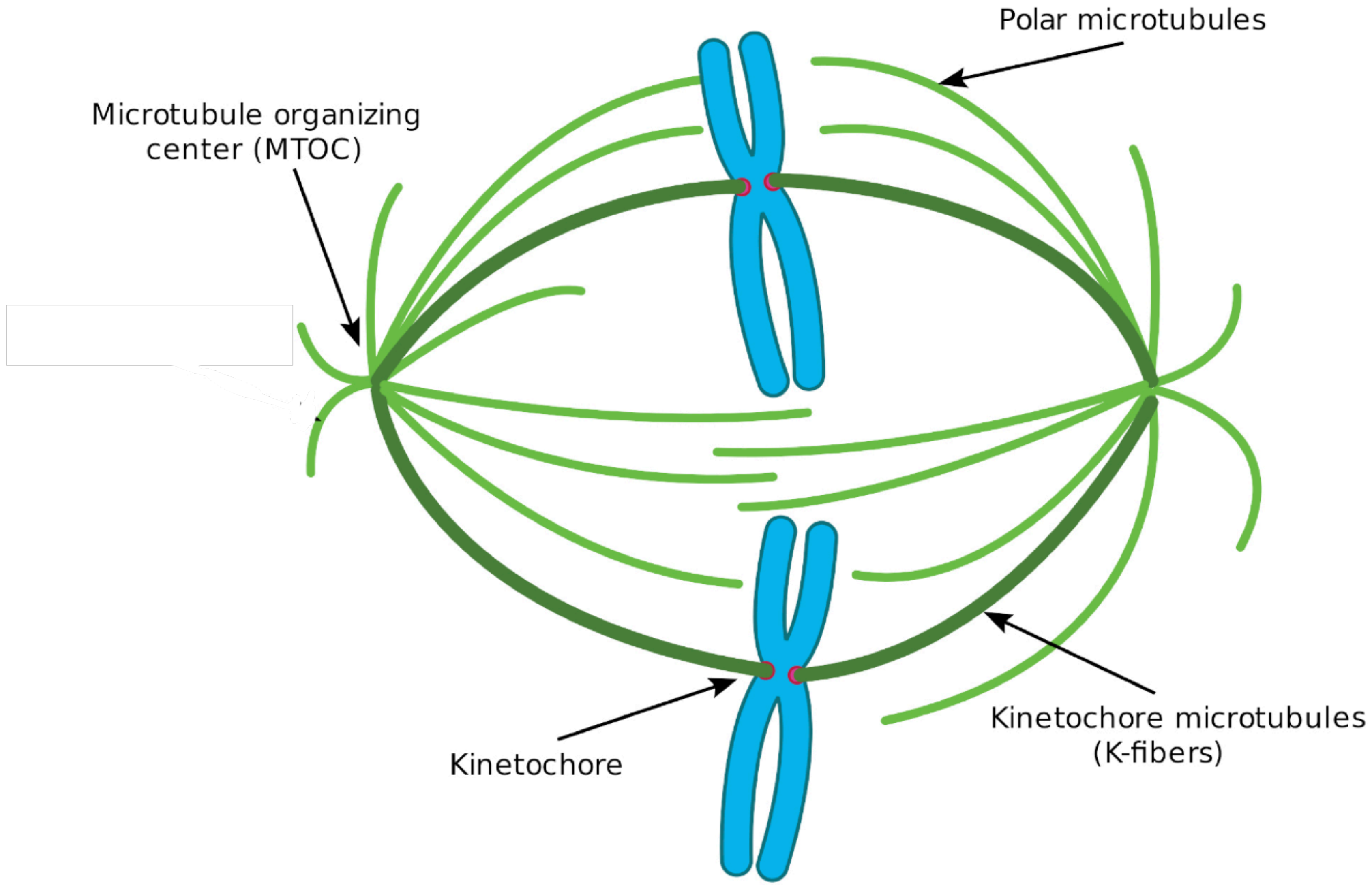

Microtubule organizing center (MTOC)

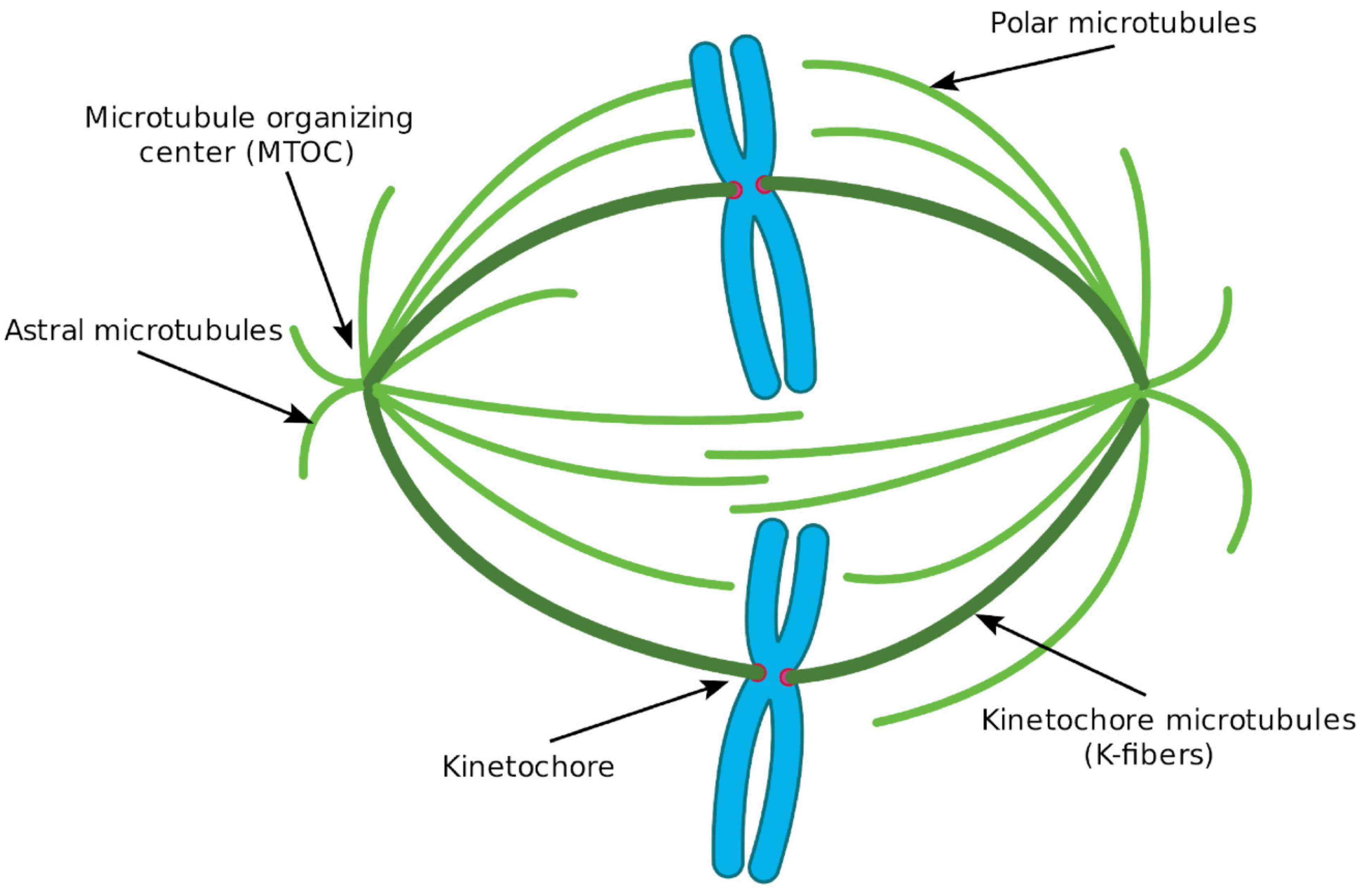


Microtubule organizing center (MTOC)
Kinetochore



Microtubule organizing center (MTOC)
Kinetochore
Kinetochore microtubules (K-fibers)


Polar microtubules
Microtubule organizing center (MTOC)
Kinetochore
Kinetochore microtubules (K-fibers)


Polar microtubules
Microtubule organizing center (MTOC)
Astral microtubules
Kinetochore
Kinetochore microtubules (K-fibers)

## Metaphase

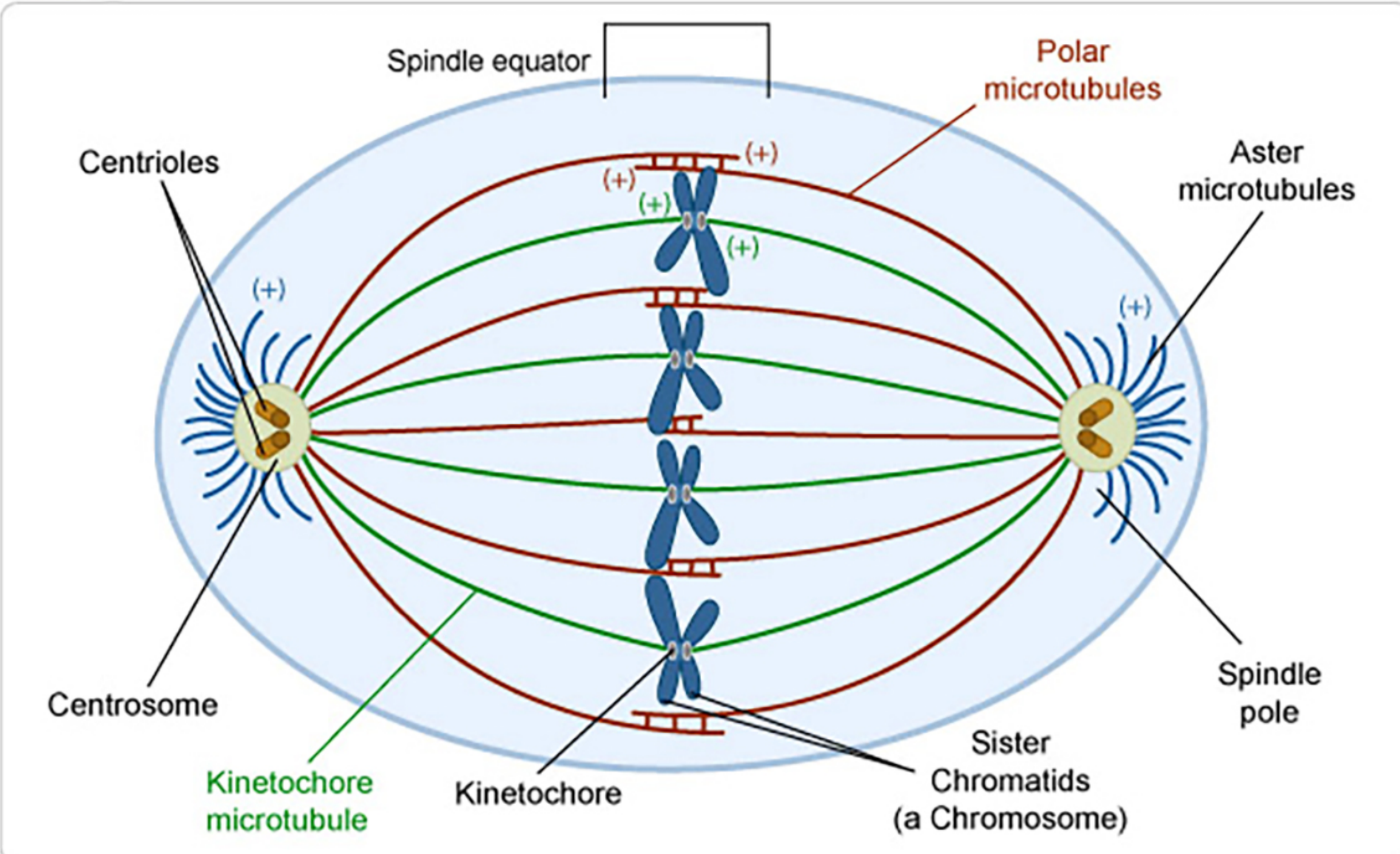





**Figure 2. The mitotic spindle at metaphase.** At metaphase, the chromosomes align at the spindle equator. Each sister chromatid of the chromosome is attached to kinetochore microtubules (shown in green). These microtubules emanate from the centrosomes at spindle poles and attach to the chromosomes at the kinetochores (one for each sister chromatid).
In addition to the kinetochore microtubules, there are two other distinct types of microtubules in the spindle: the polar microtubules (shown in red), which grow out from the centrosomes and have opposing microtubules overlapping at the spindle equator; and the aster microtubules (shown in blue), which grow out from the centrosomes toward the cortex of the cell. For all three types of microtubules, the minus ends are at the centrosomes and the plus ends (indicated as +) grow away from the centrosomes.

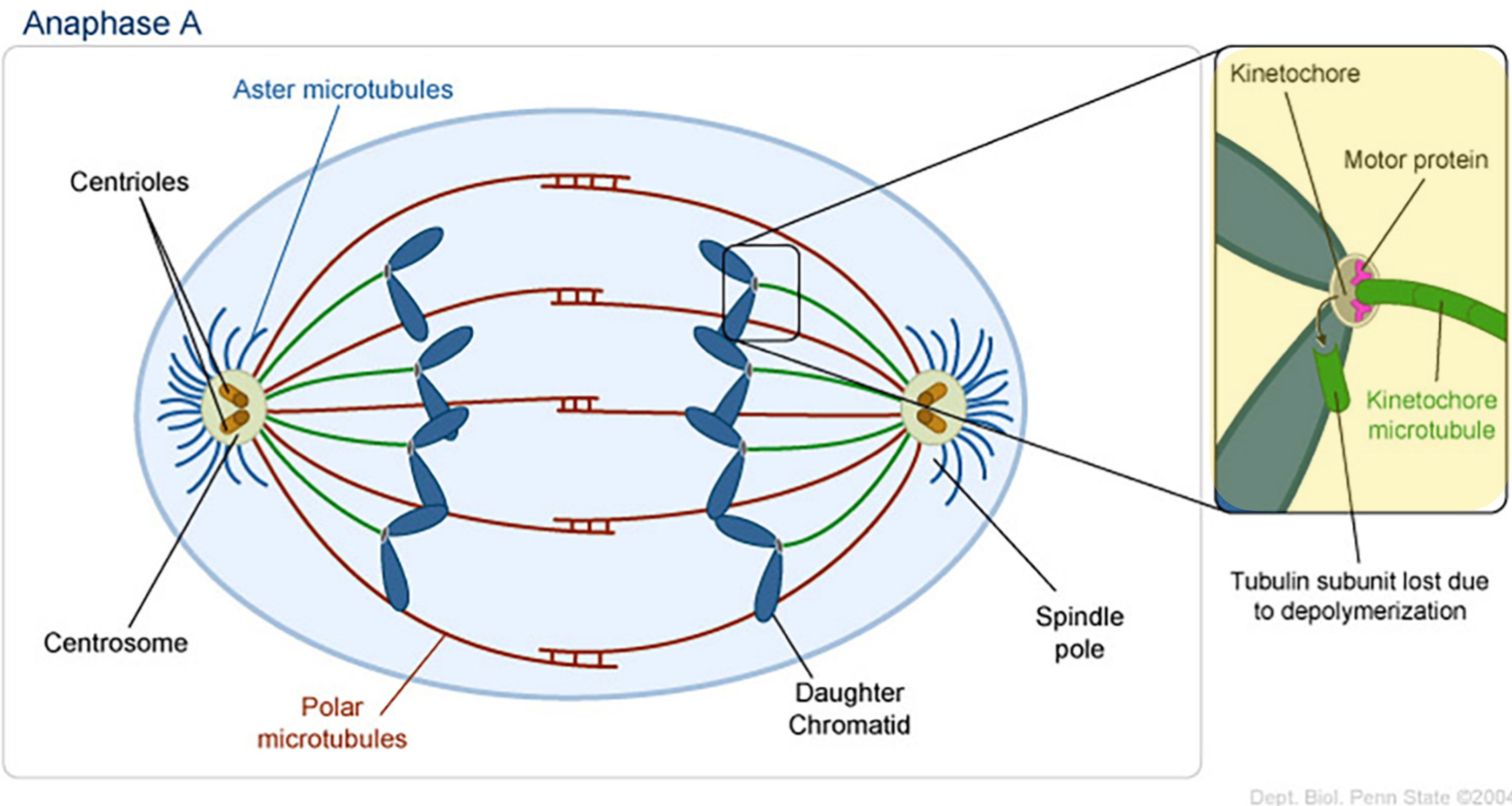



**Figure 3. The mitotic spindle at anaphase A.** During anaphase A, the pairs of sister chromatids are separated and move toward the spindle poles. This occurs through the action of the kinetochore microtubules (illustrated in the inset). These microtubules shorten at their plus ends, while the motor proteins attached to the kinetochores of the chromatids travel toward the minus ends; thereby, the sister chromatids remain attached to the shortening microtubules.

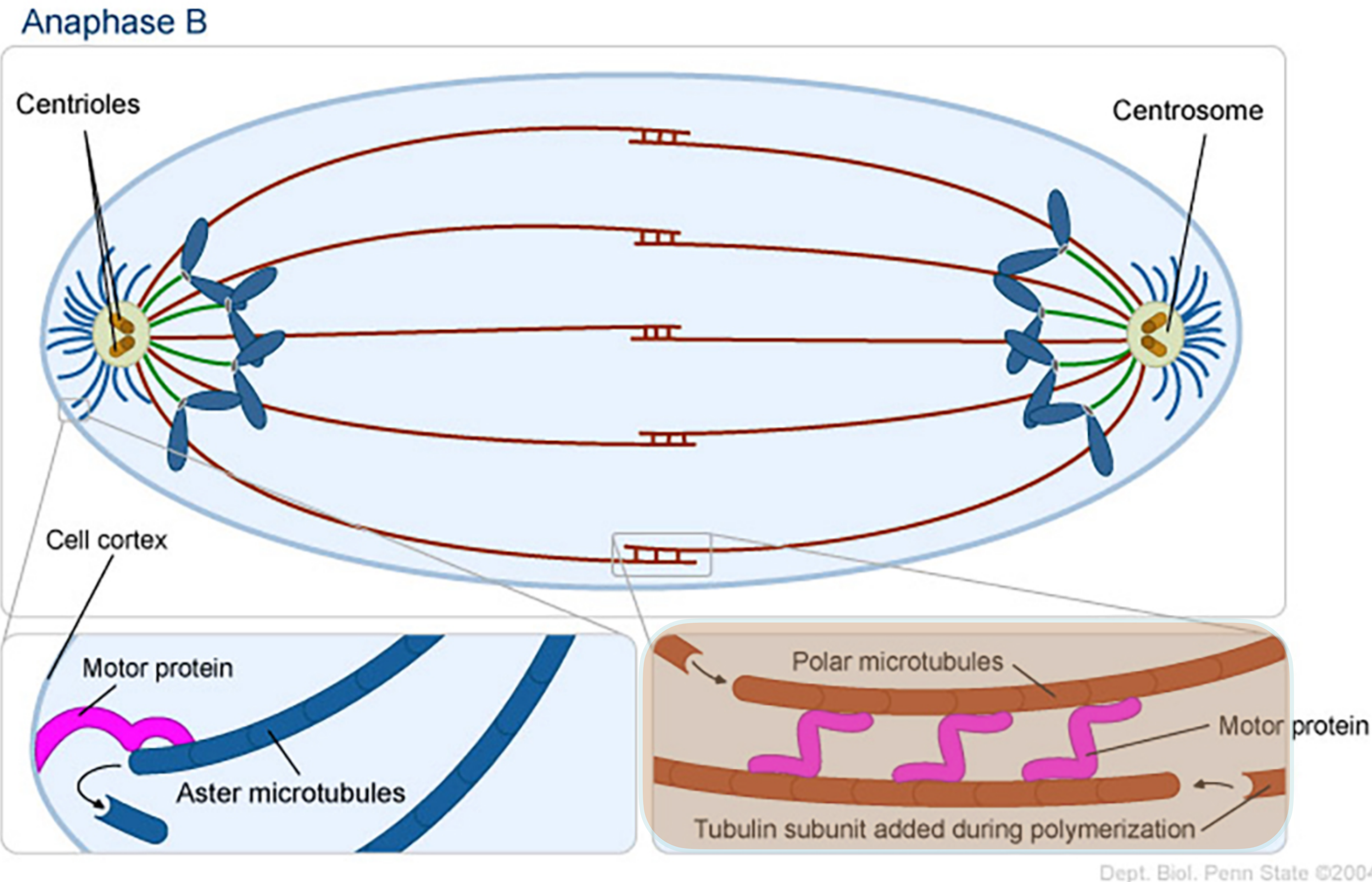



**Figure 4. The mitotic spindle at anaphase B.** During anaphase B, the spindle poles move further apart. This occurs through the combined action of the polar microtubules and the aster microtubules.

The action of the polar microtubules is shown in the inset on the right. Overlapping polar microtubules grow by polymerization at their plus ends, while the cross-linked motor proteins travel toward the plus ends, thereby pushing the overlapping polar microtubules past each other and the spindle poles further apart. The action of the aster microtubules is shown in the inset to the left. The aster microtubules depolymerize at their plus ends, while the motor proteins linked to the cell's cortex travel toward the minus ends, thereby pulling the attached spindle poles closer to the cortex and further apart from each other.

# MITOSIS

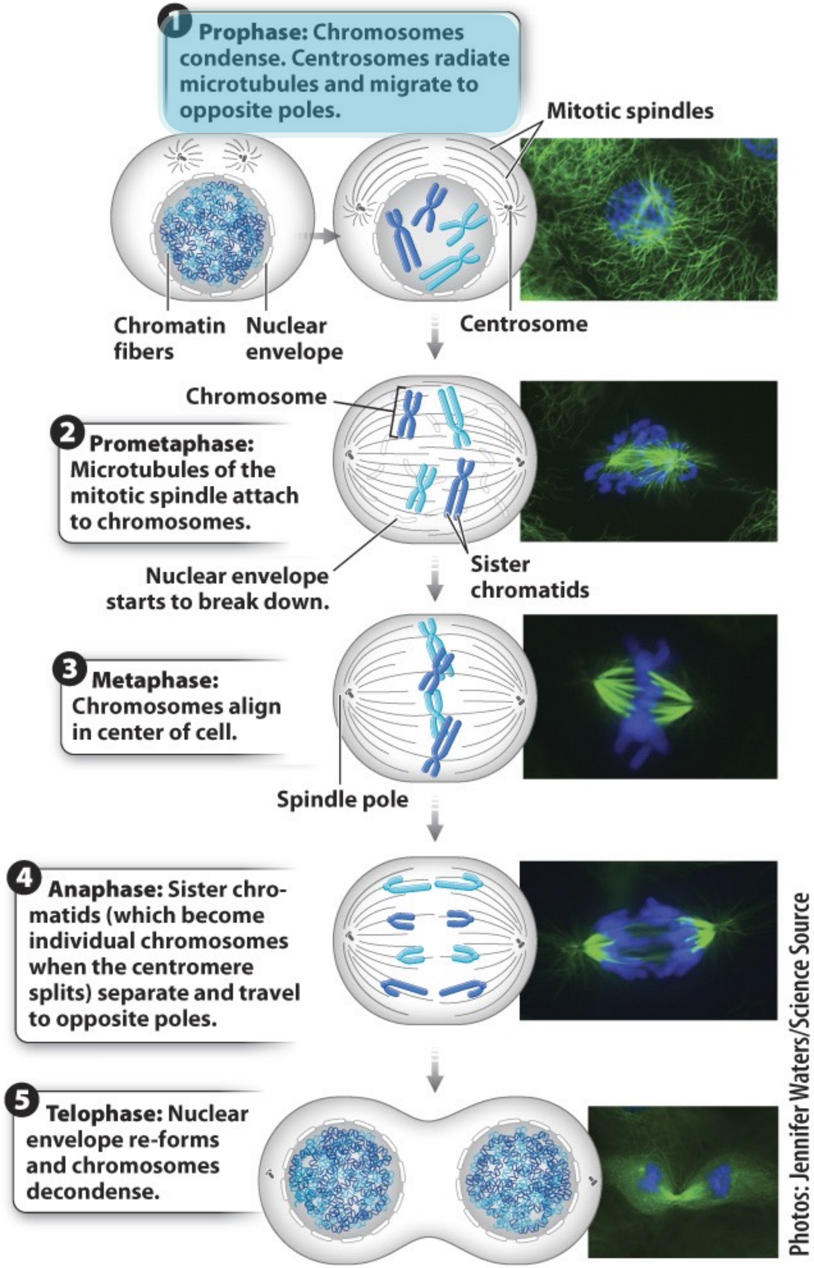
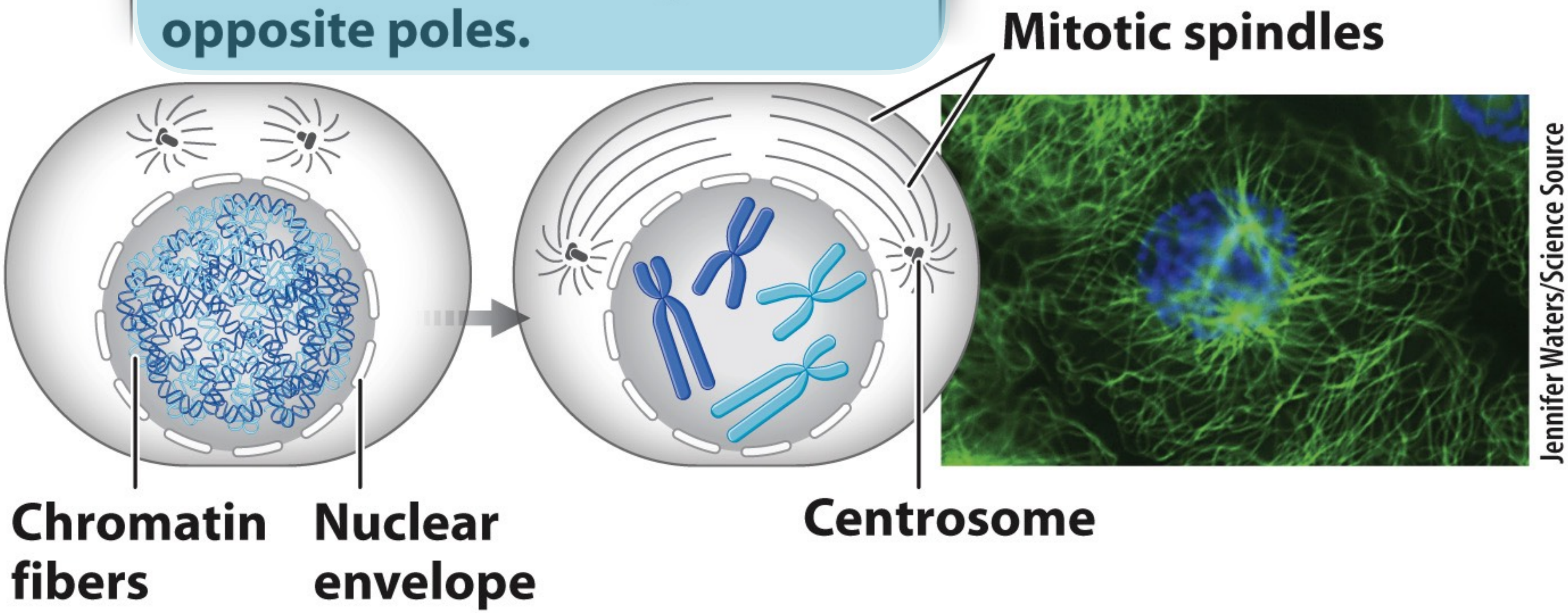
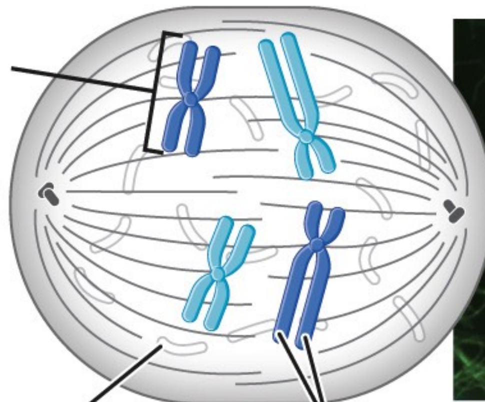


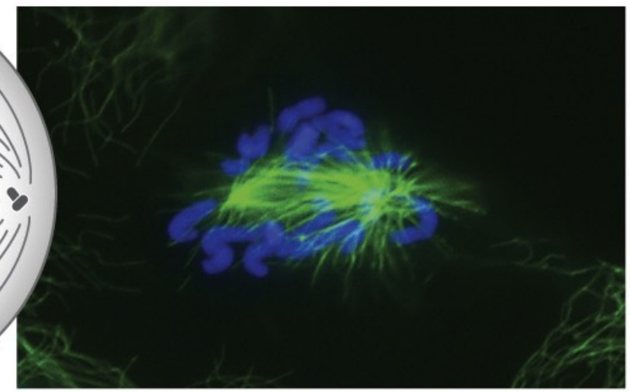

**Figure 11.5**
*Biology: How Life Works*, Second Edition

**1 Prophase: Chromosomes condense. Centrosomes radiate microtubules and migrate to opposite poles.**

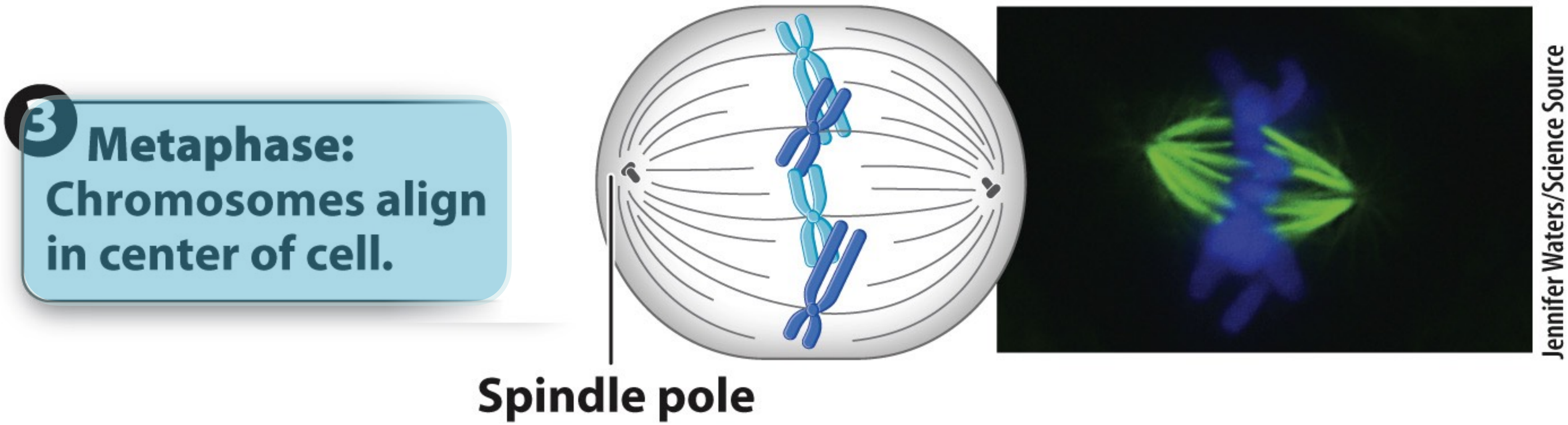


**2 Prometaphase: Microtubules of the mitotic spindle attach to chromosomes.**



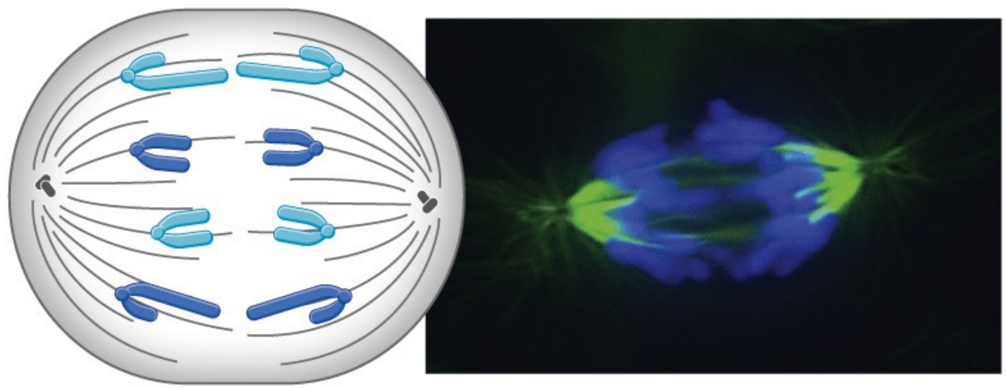



Jennifer Waters/Science Source


3
Metaphase:
Chromosomes align
in center of cell.
Spindle pole
Jennifer Waters/Science Source

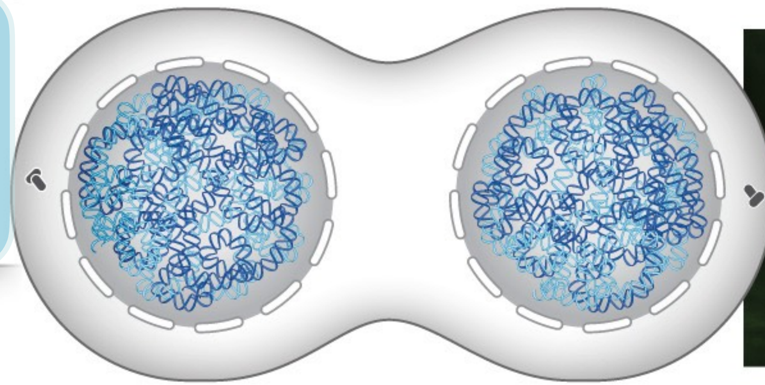
“single file”

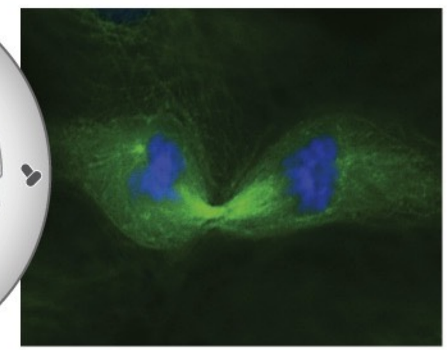
**4 Anaphase: Sister chromatids (which become individual chromosomes when the centromere splits) separate and travel to opposite poles.**



Jennifer Waters/Science Source

**5 Telophase: Nuclear envelope re-forms and chromosomes decondense.**





Jennifer Waters/Science Source

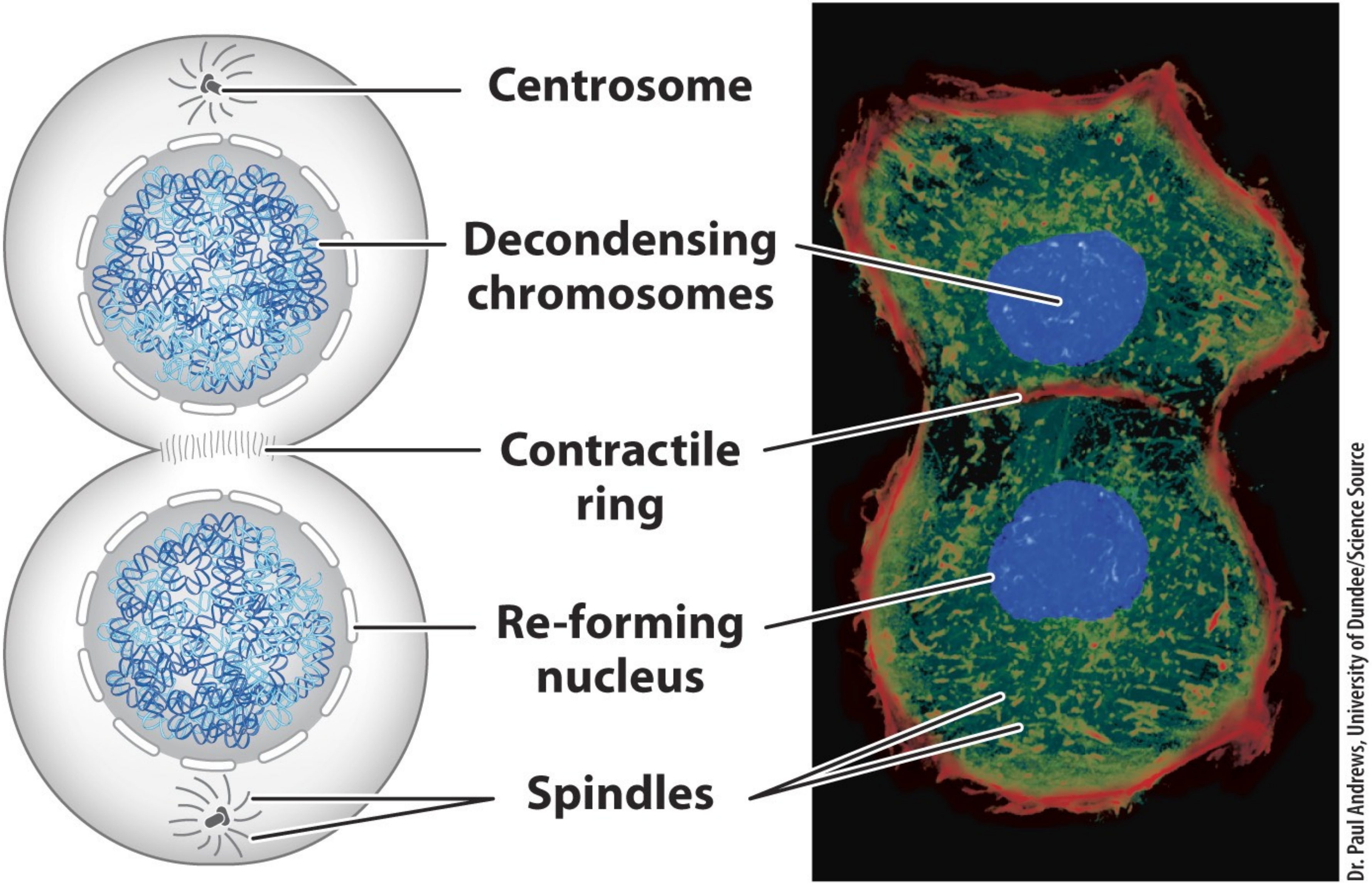



**Figure 11.7a**
*Biology: How Life Works*, Second Edition

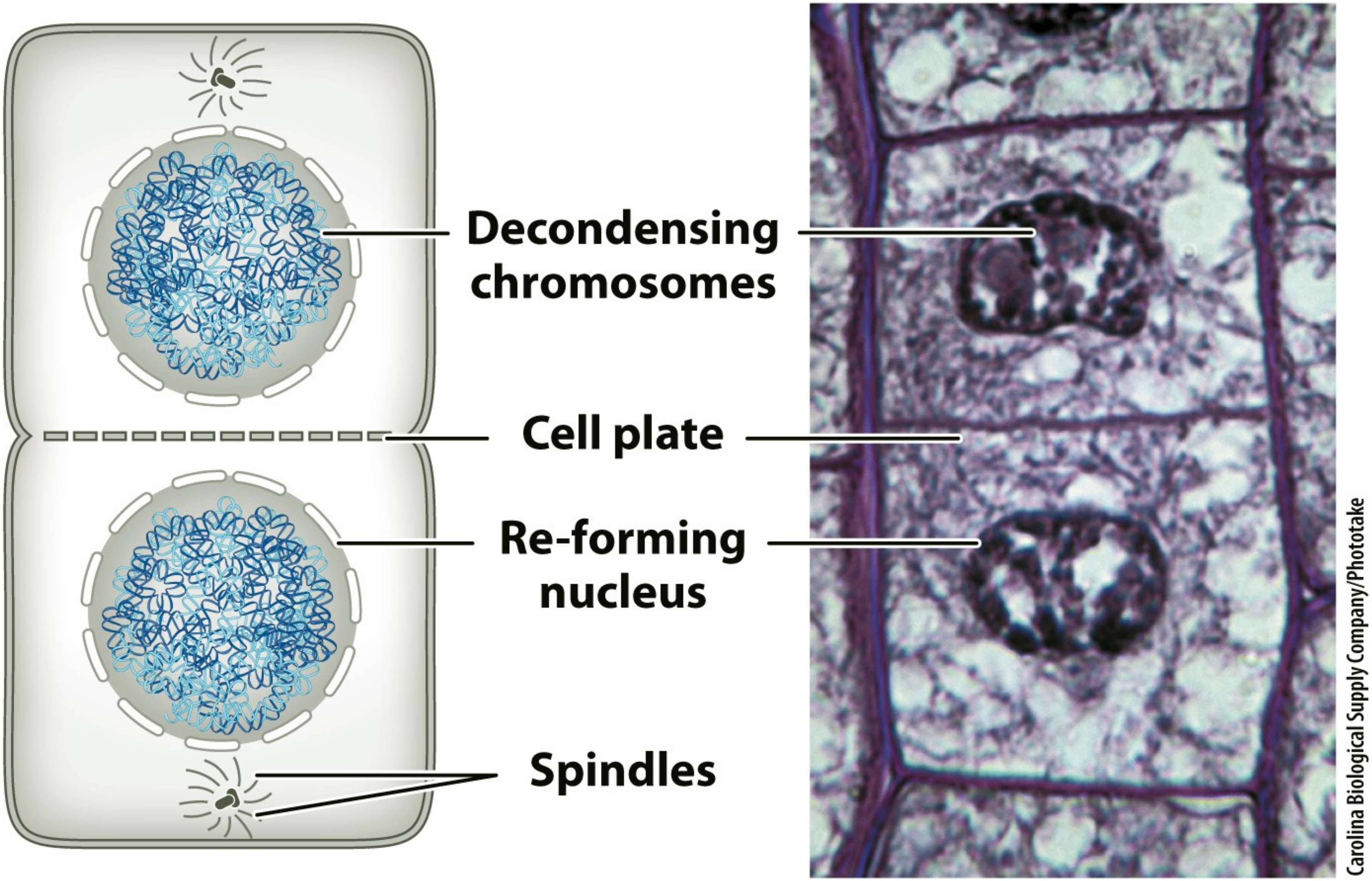
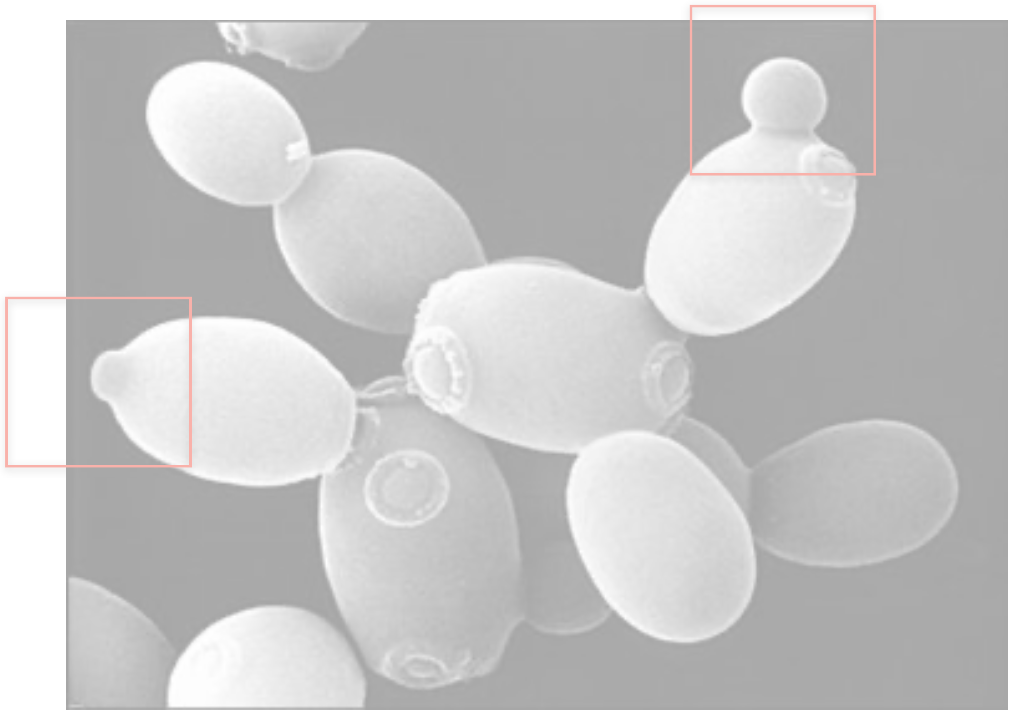



**Figure 11.7b**
*Biology: How Life Works*, Second Edition

**Mitosis:** **The Distribution of EXACT COPIES of Genetic Information, whereby a single cell, gives rise to two genetically "identical" cells: but more specifically, a single nucleus gives rise to two genetically "identical" nuclei, one for each of the two new daughter cells.**

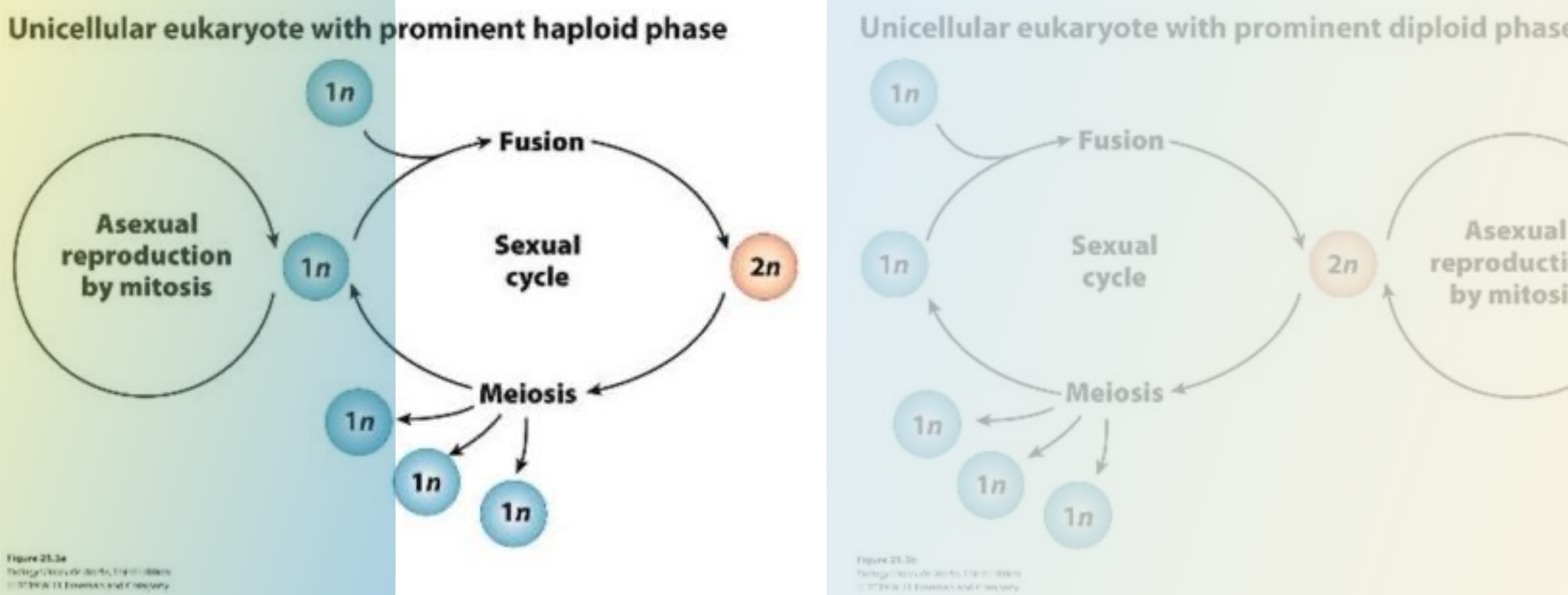
**Asexual reproduction** involves the generation of a new individuals that are effectively genetically "identical" to the parent. It involves a cell or cells that were generated by **mitosis**.



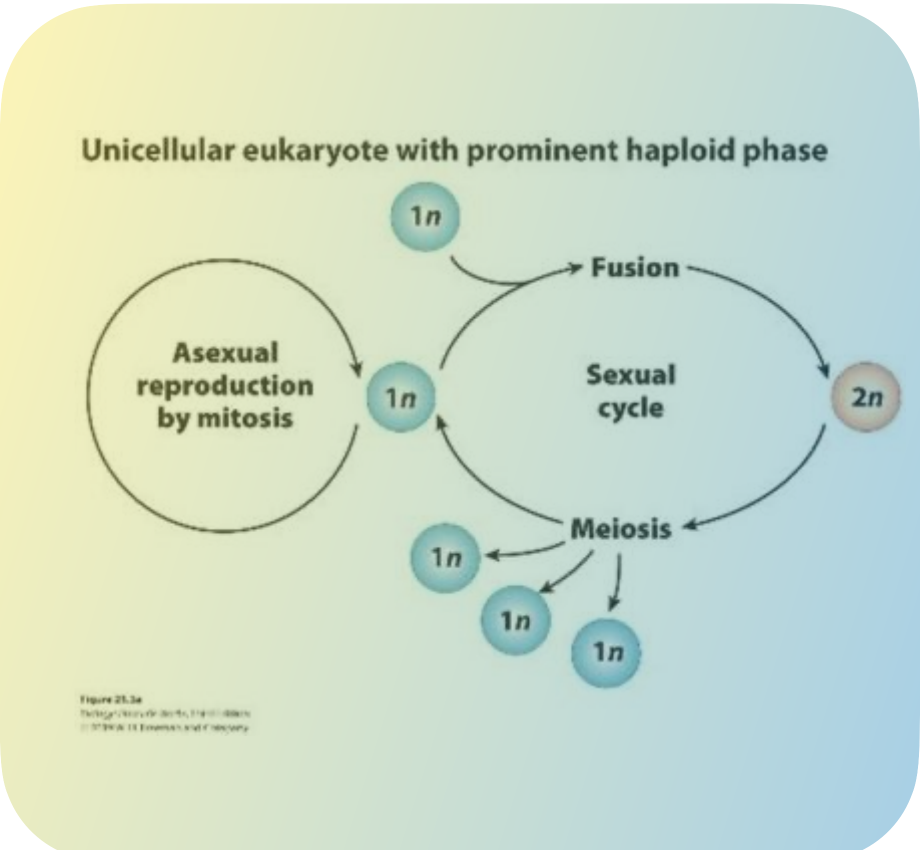
*LIFE: THE SCIENCE OF BIOLOGY*, Seventh Edition, Figure 9.11 Asexual Reproduction

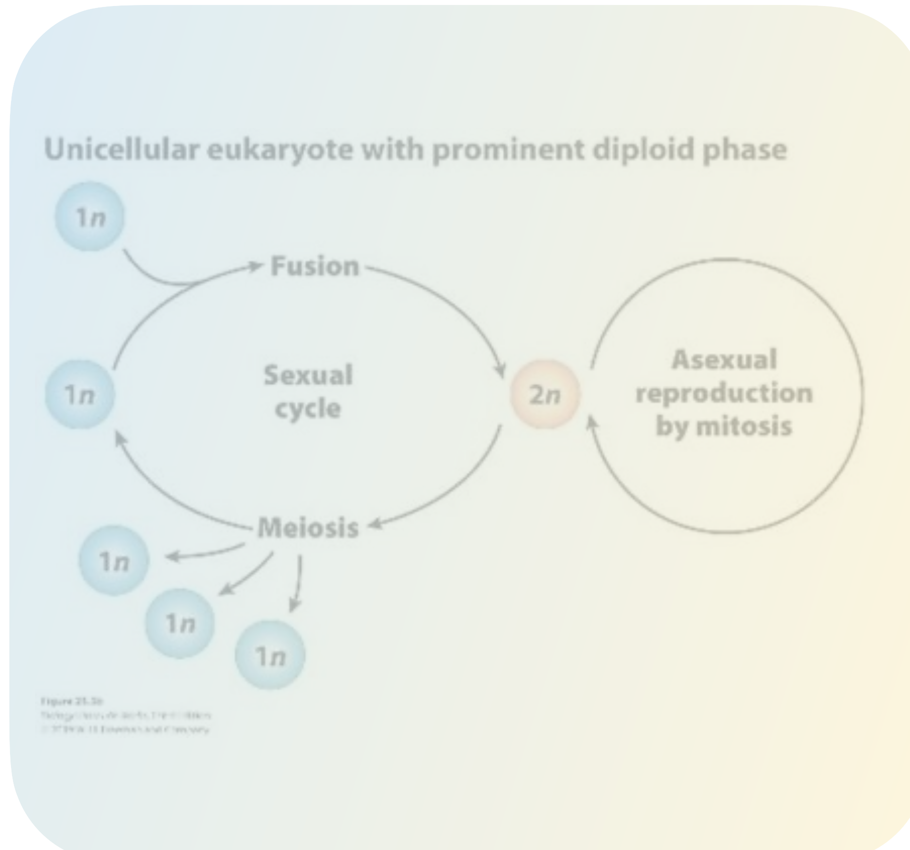

- Variation of cells is principally due, therefore to the "forces of evolution" that we have discussed previously...
- **NS**, **GD**, **GF** and **Muts**,-as well as other potential **environmental effects**.

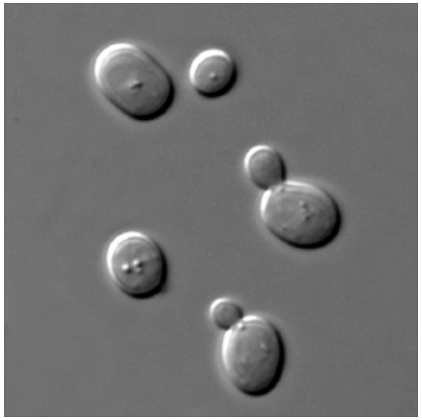
# Eukaryotic Life Cycles (1/2)



# Eukaryotic Life Cycles (1/2)

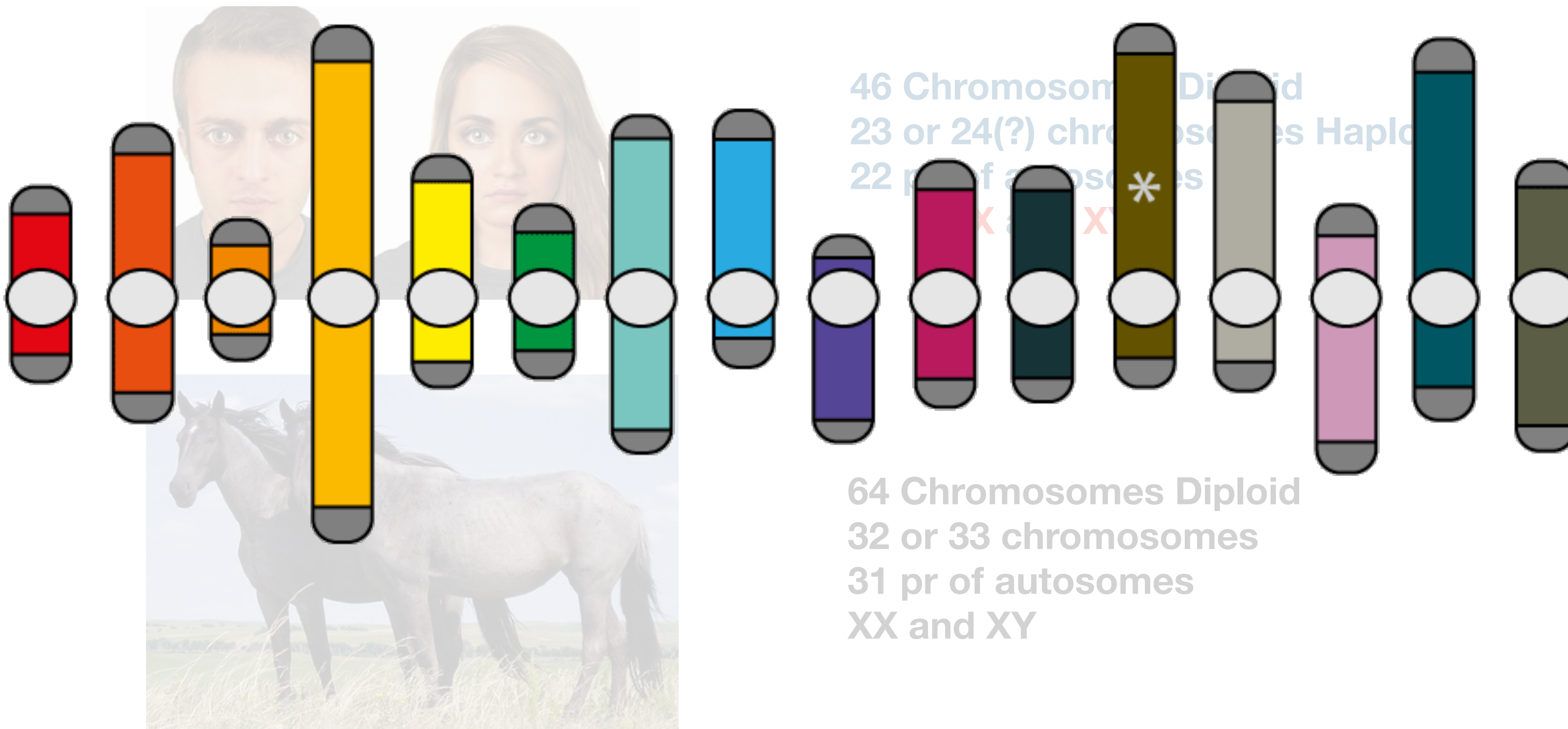




16 chromosomes Haploid
32 chromosomes Diploid

16 pr of chromosomes (D)



# Eukaryotic Life Cycle in Animals

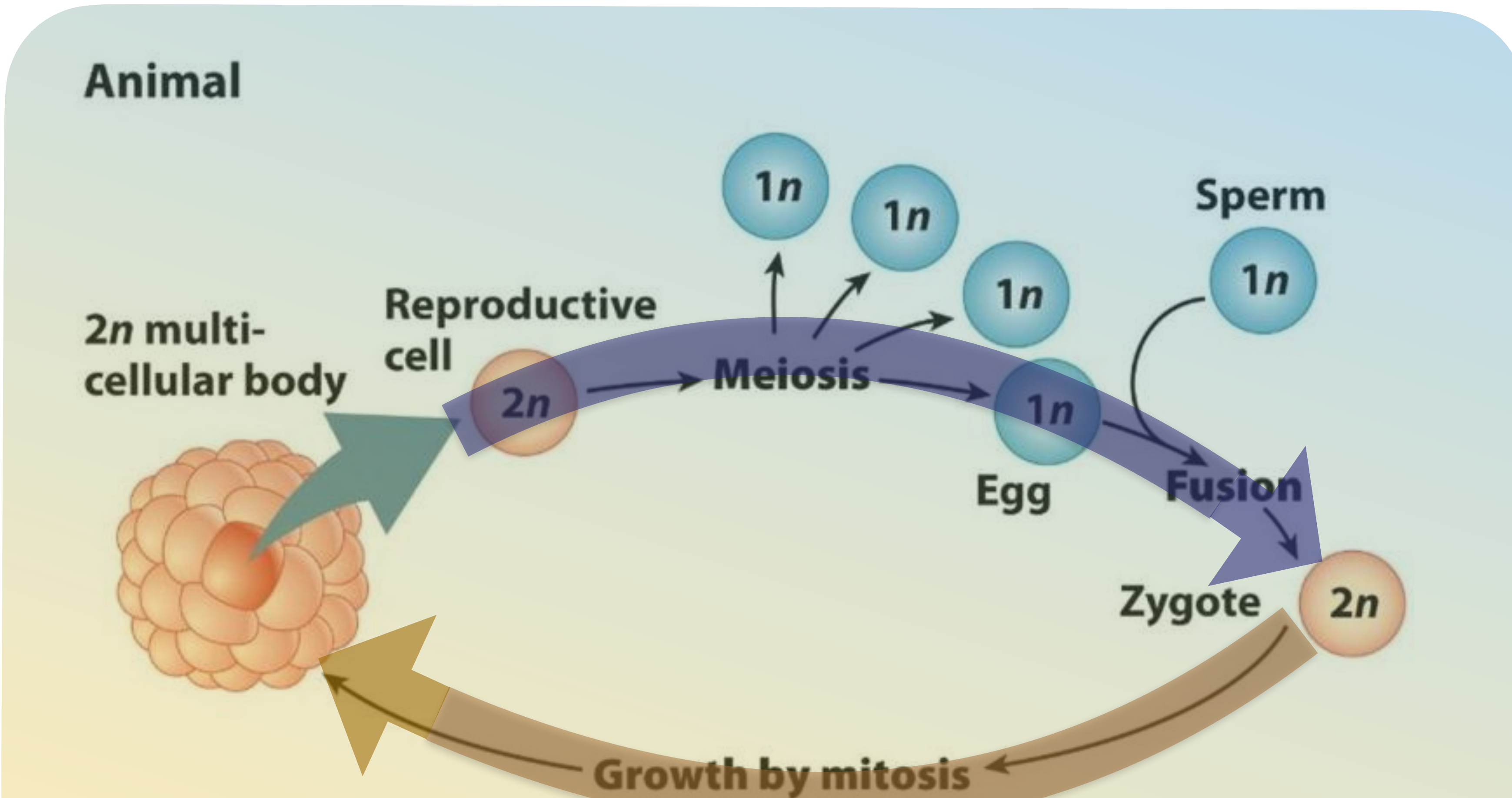
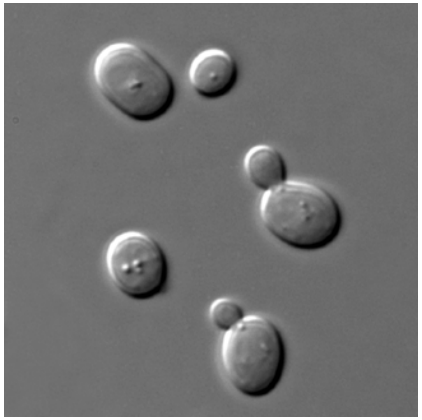



Figure 25.3c
*Biology: How Life Works*, Third Edition



16 chromosomes Haploid
32 chromosomes Diploid

16 pr of chromosomes (D)

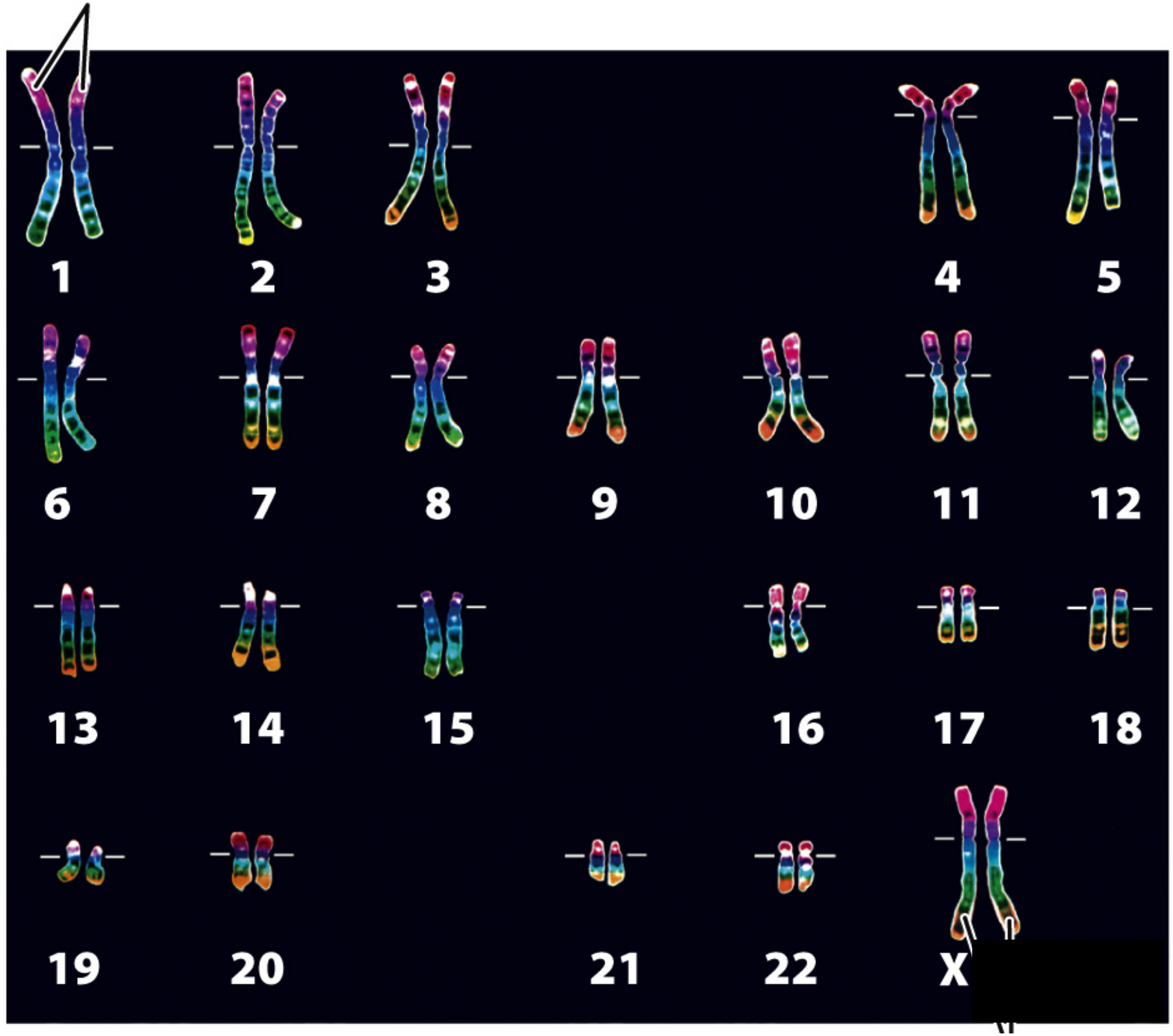


46 Chromosomes Diploid
23 or 24(?) chromosomes Haploid
22 pr. of autosomes
XX and XY

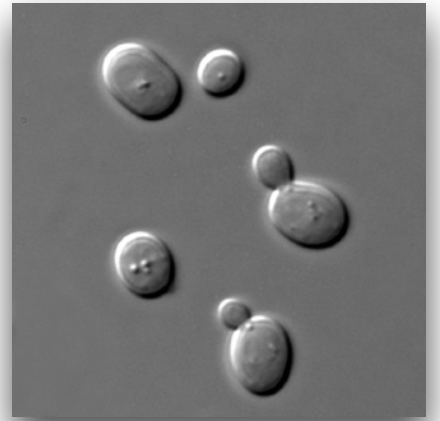


64 Chromosomes Diploid
32 or 33 chromosomes
31 pr of autosomes
XX and XY

# Karyotyping

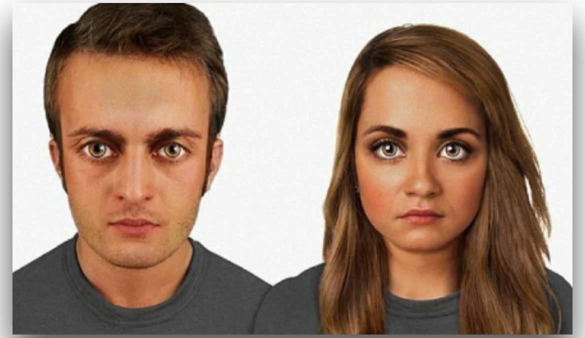



ISM/Phototake



16 chromosomes Haploid
32 chromosomes Diploid

16 pr of chromosomes (D)

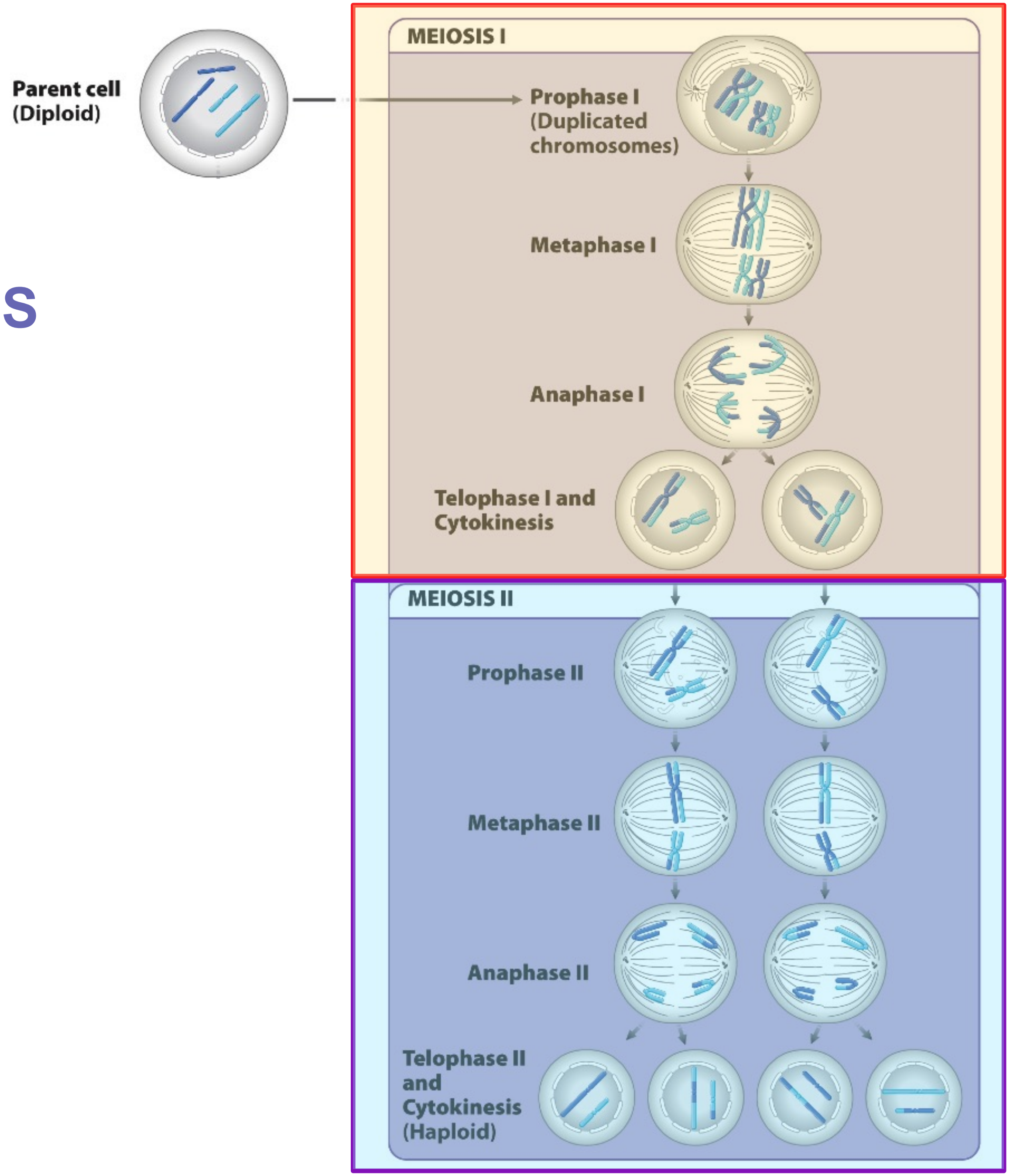


46 Chromosomes Diploid
23 chromosomes Haploid
22 pr. of autosomes
XX and XY

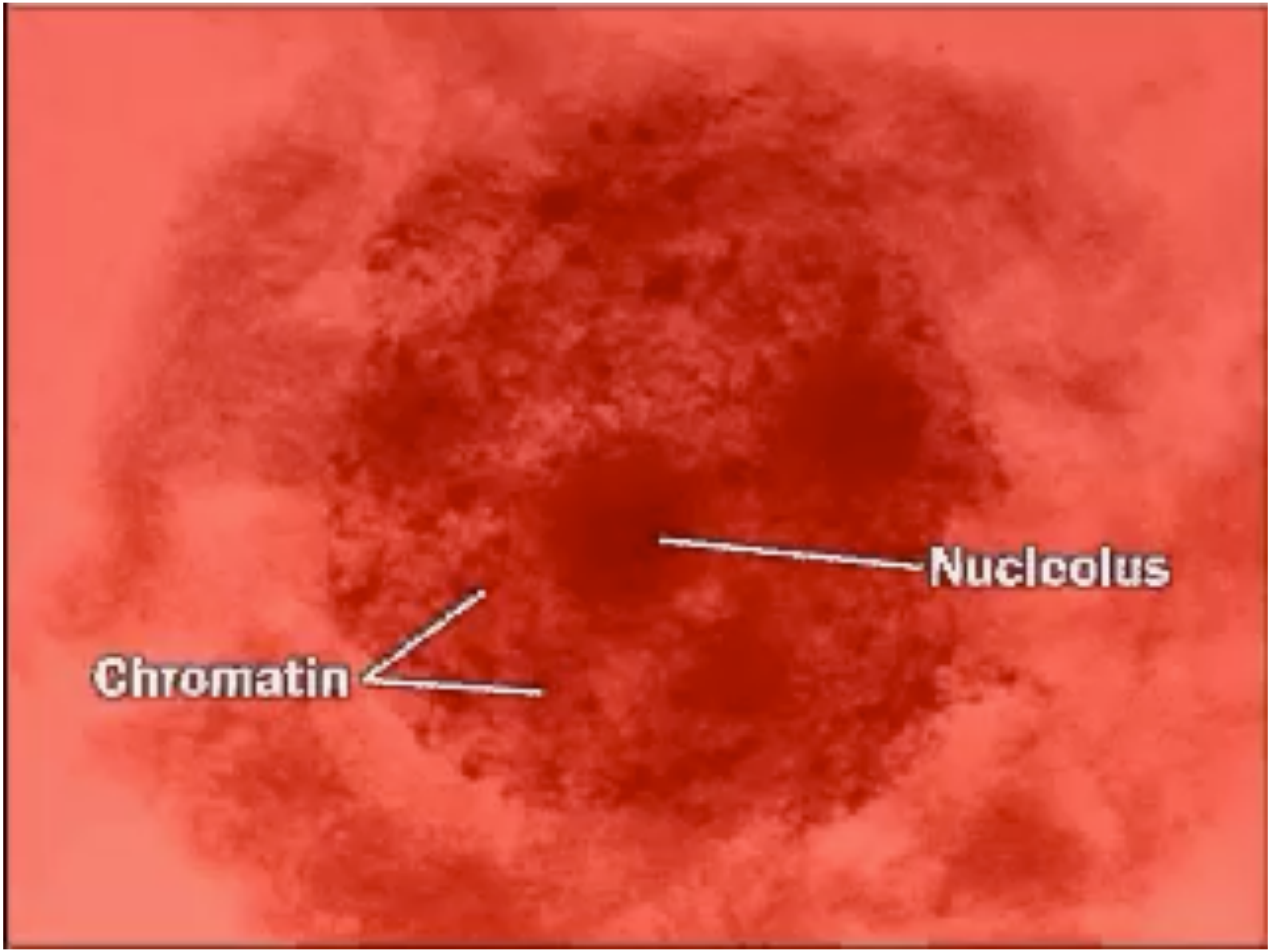


64 Chromosomes Diploid
32 chromosomes
31 pr of autosomes
XX and XY

# MEIOSIS



Parent cell
(Diploid)
MEIOSIS I
Prophase I
(Duplicated
chromosomes)
Metaphase I
Anaphase I
Telophase I and
Cytokinesis
MEIOSIS II
Prophase II
Metaphase II
Anaphase II
Telophase II
and
Cytokinesis
(Haploid)


Nucleolus
Chromatin

# 1 Prophase I

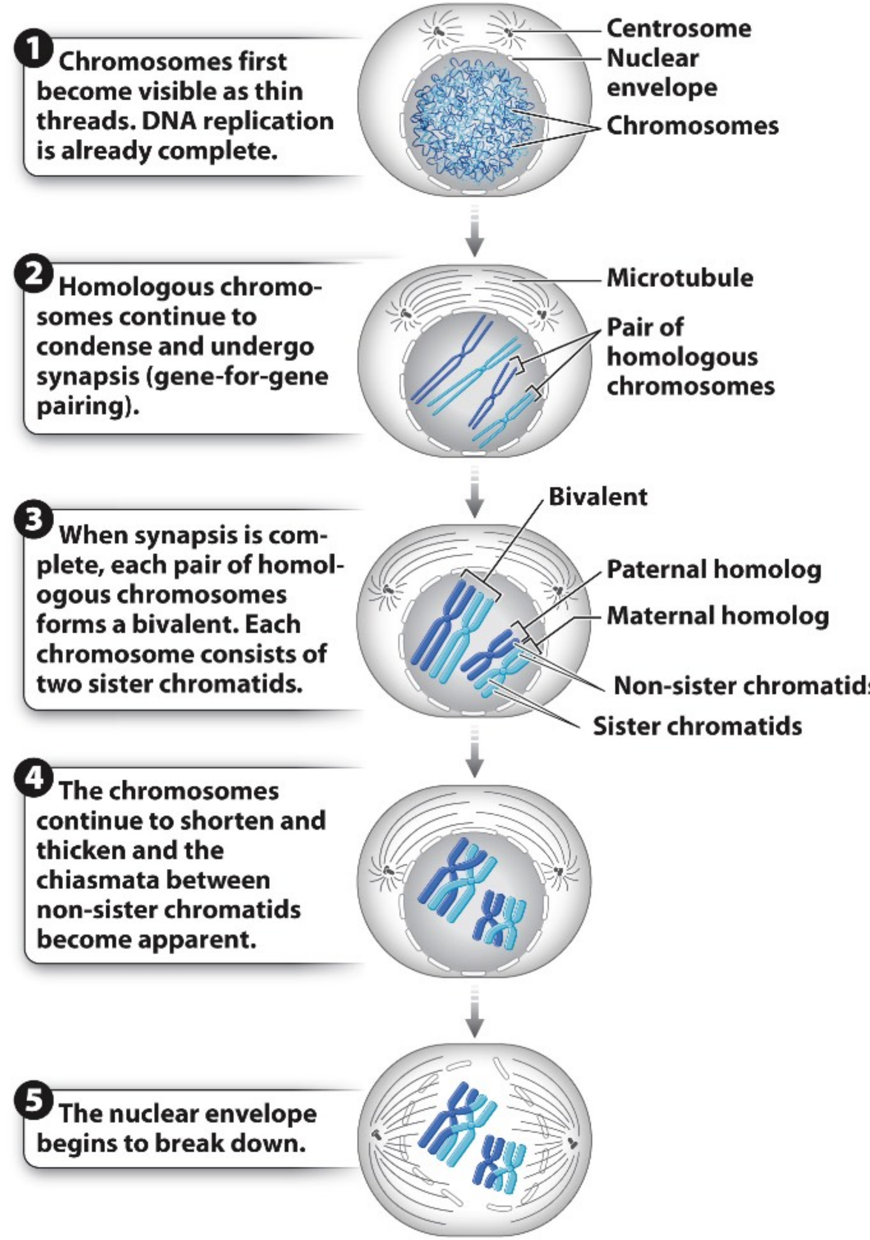
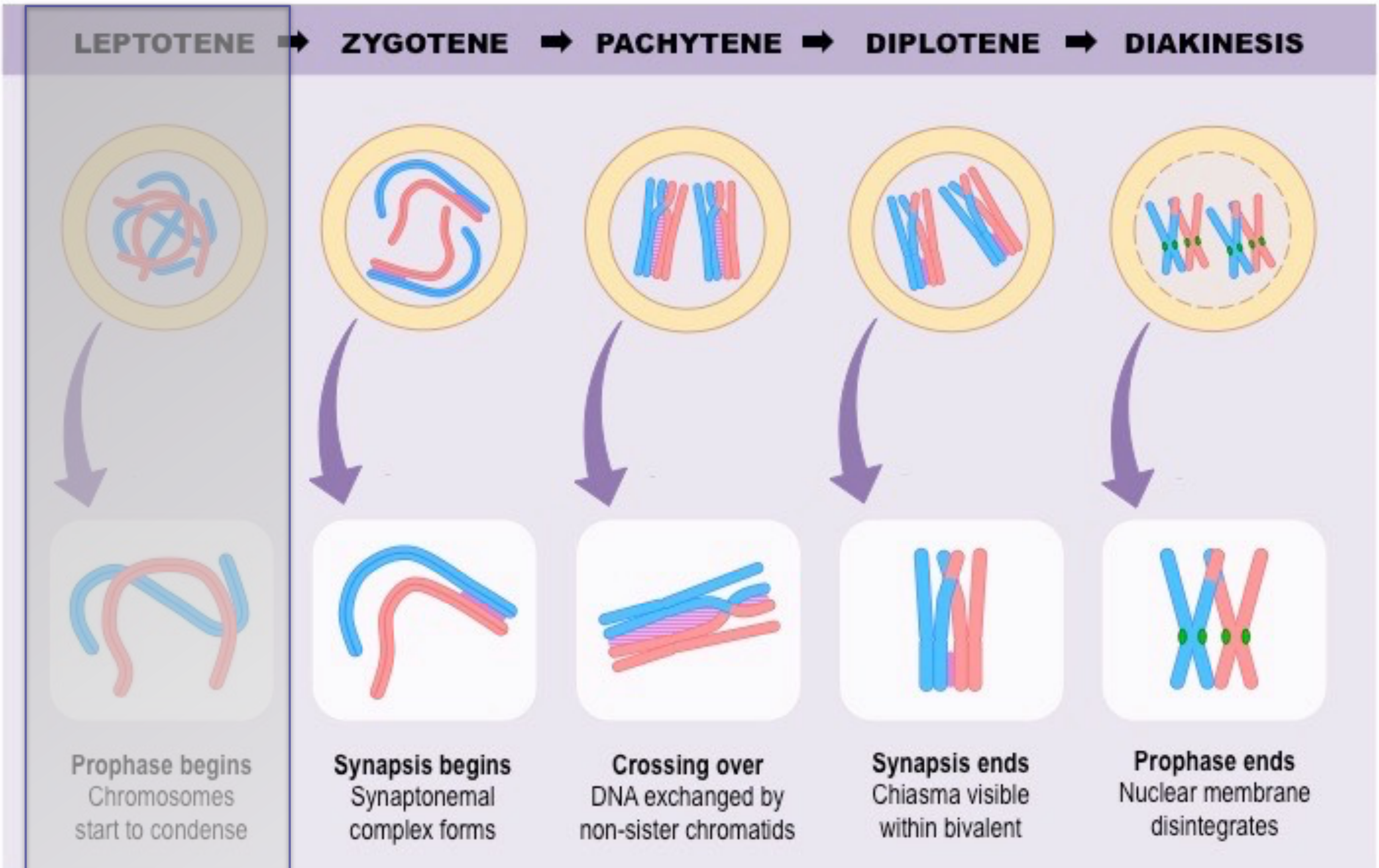


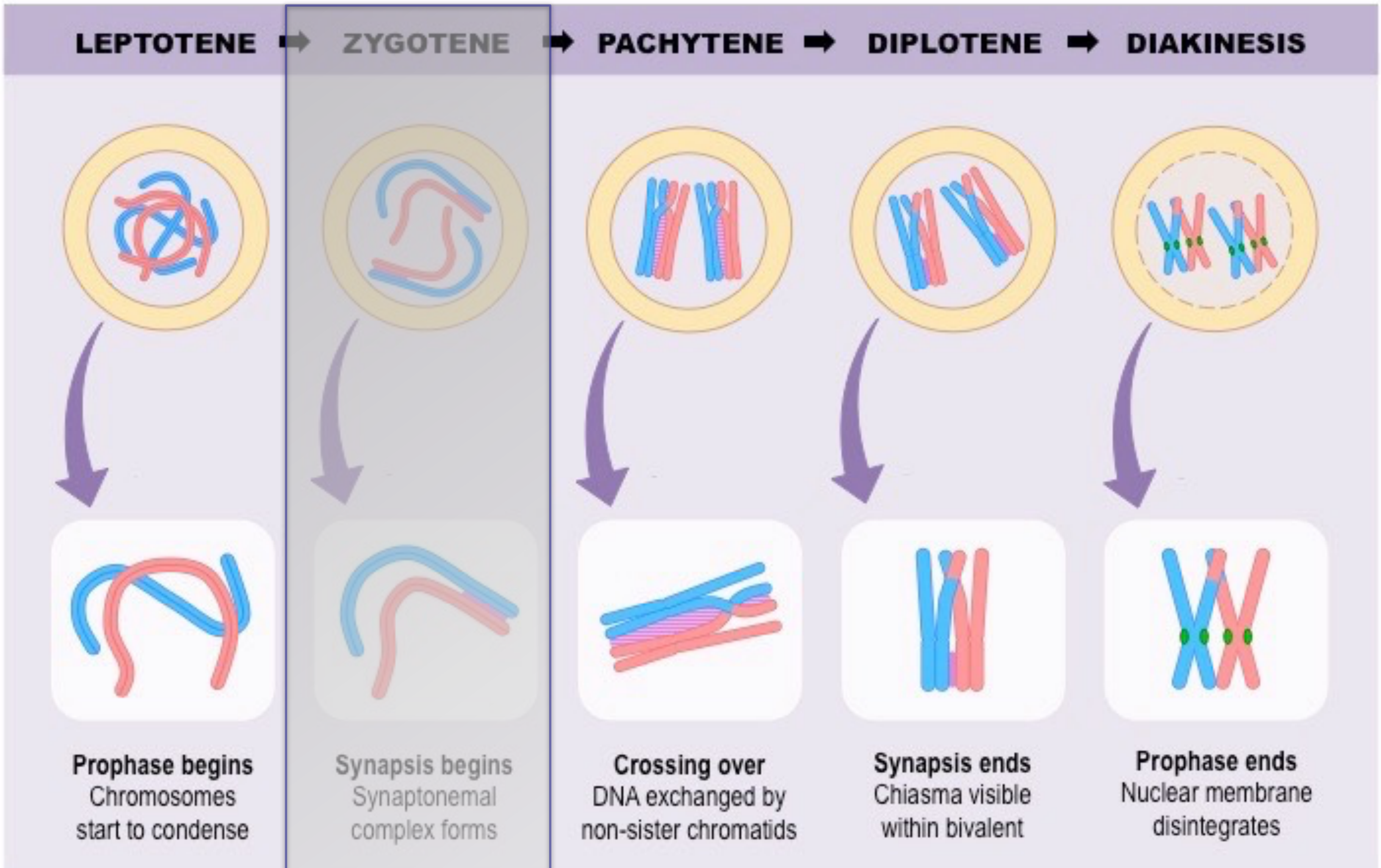

**Figure 11.8**
*Biology: How Life Works*, Second Edition

## 1 Prophase I



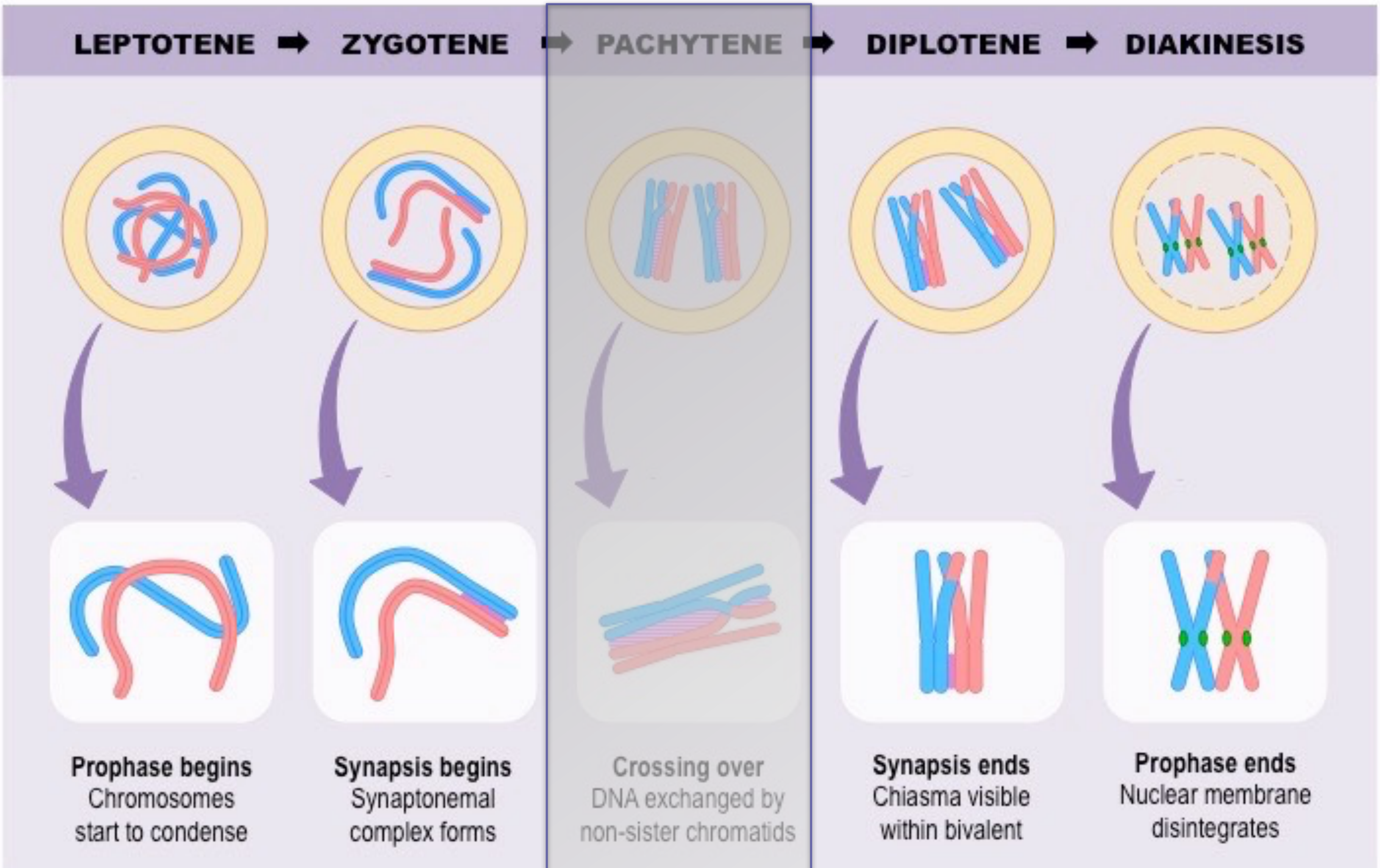
LEPTOTENE
ZYGOTENE
PACHYTENE
DIPLOTENE
DIAKINESIS
Prophase begins
Chromosomes start to condense
Synapsis begins
Synaptonemal complex forms
Crossing over
DNA exchanged by non-sister chromatids
Synapsis ends
Chiasma visible within bivalent
Prophase ends
Nuclear membrane disintegrates

## 1 Prophase I



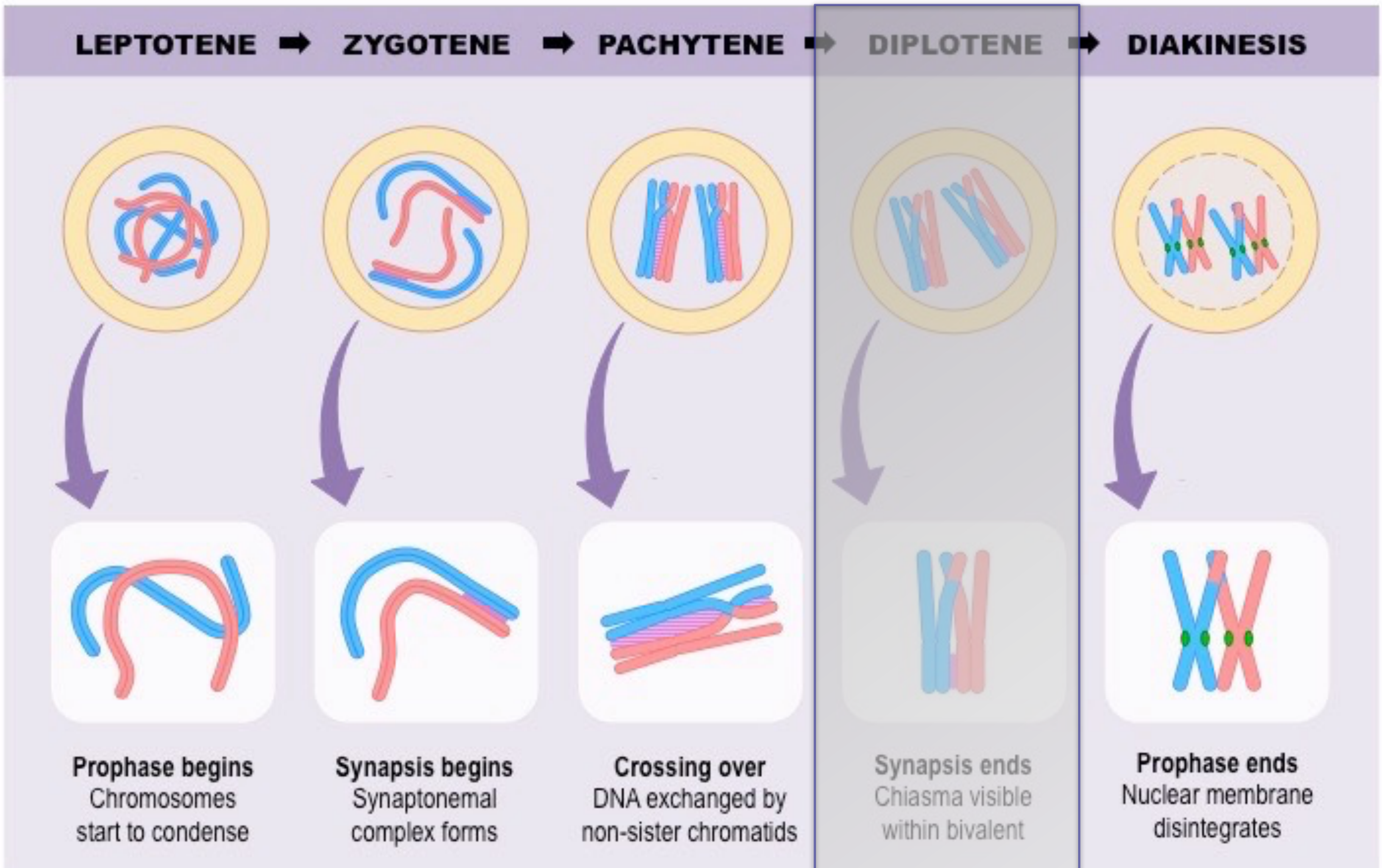
LEPTOTENE
ZYGOTENE
PACHYTENE
DIPLOTENE
DIAKINESIS
Prophase begins
Chromosomes start to condense
Synapsis begins
Synaptonemal complex forms
Crossing over
DNA exchanged by non-sister chromatids
Synapsis ends
Chiasma visible within bivalent
Prophase ends
Nuclear membrane disintegrates

# 1 Prophase I

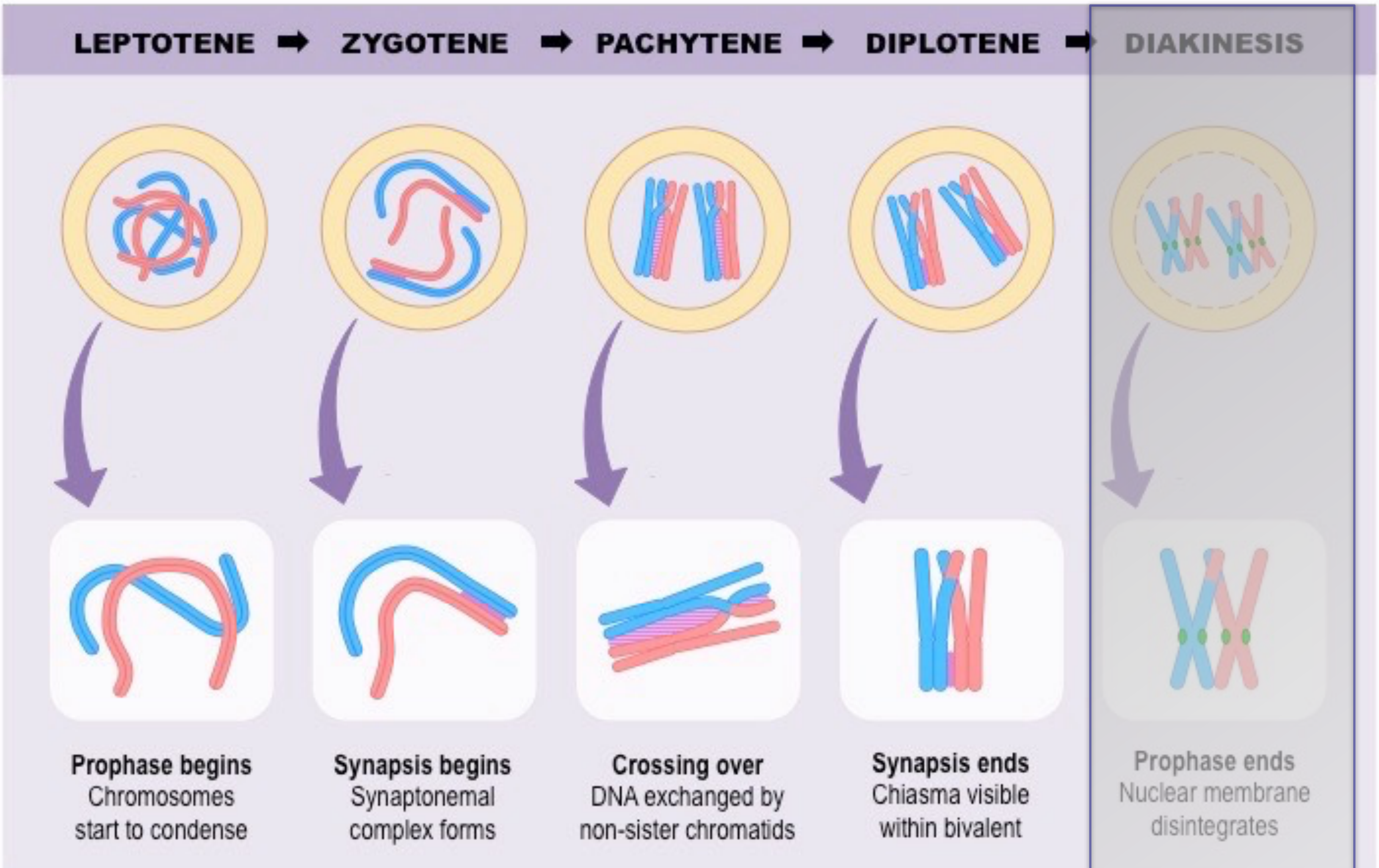


LEPTOTENE
ZYGOTENE
PACHYTENE
DIPLOTENE
DIAKINESIS
Prophase begins
Chromosomes start to condense
Synapsis begins
Synaptonemal complex forms
Crossing over
DNA exchanged by non-sister chromatids
Synapsis ends
Chiasma visible within bivalent
Prophase ends
Nuclear membrane disintegrates

## 1 Prophase I

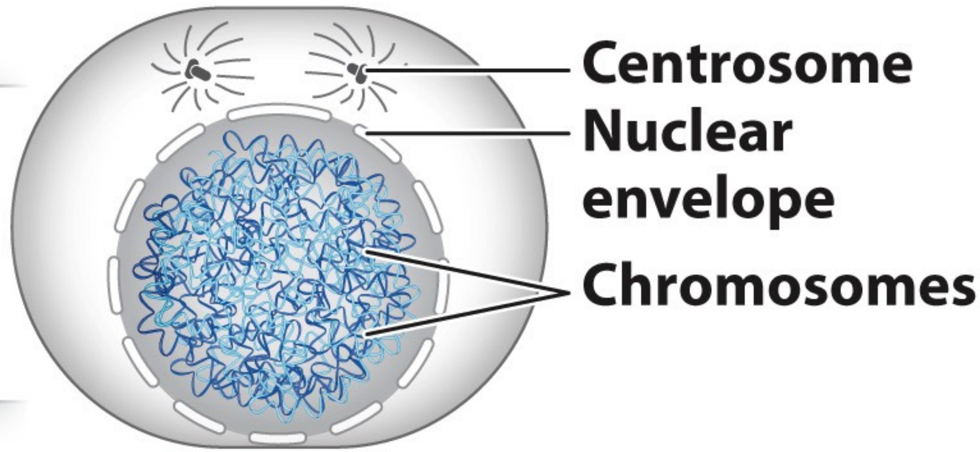

LEPTOTENE
ZYGOTENE
PACHYTENE
DIPLOTENE
DIAKINESIS
Prophase begins
Chromosomes start to condense
Synapsis begins
Synaptonemal complex forms
Crossing over
DNA exchanged by non-sister chromatids
Synapsis ends
Chiasma visible within bivalent
Prophase ends
Nuclear membrane disintegrates

## 1 Prophase I

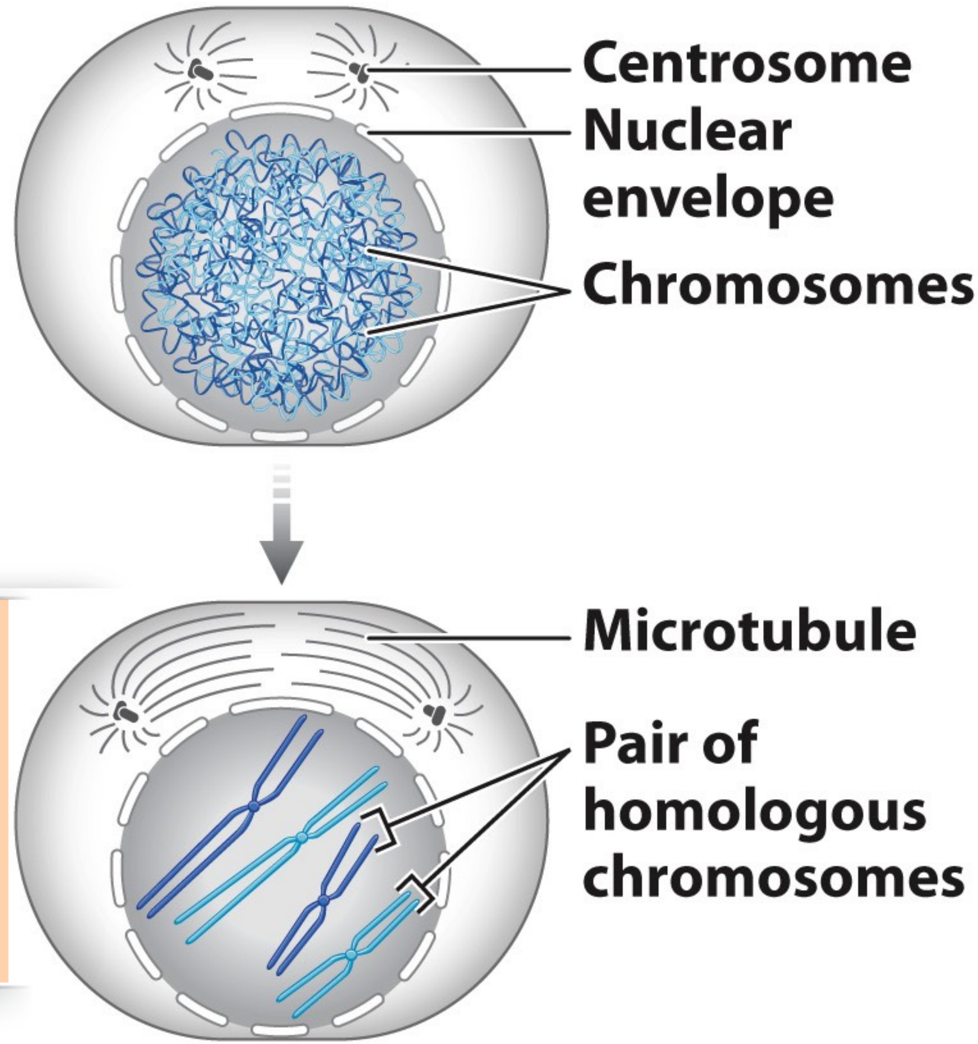


LEPTOTENE
ZYGOTENE
PACHYTENE
DIPLOTENE
DIAKINESIS
Prophase begins
Chromosomes start to condense
Synapsis begins
Synaptonemal complex forms
Crossing over
DNA exchanged by non-sister chromatids
Synapsis ends
Chiasma visible within bivalent
Prophase ends
Nuclear membrane disintegrates

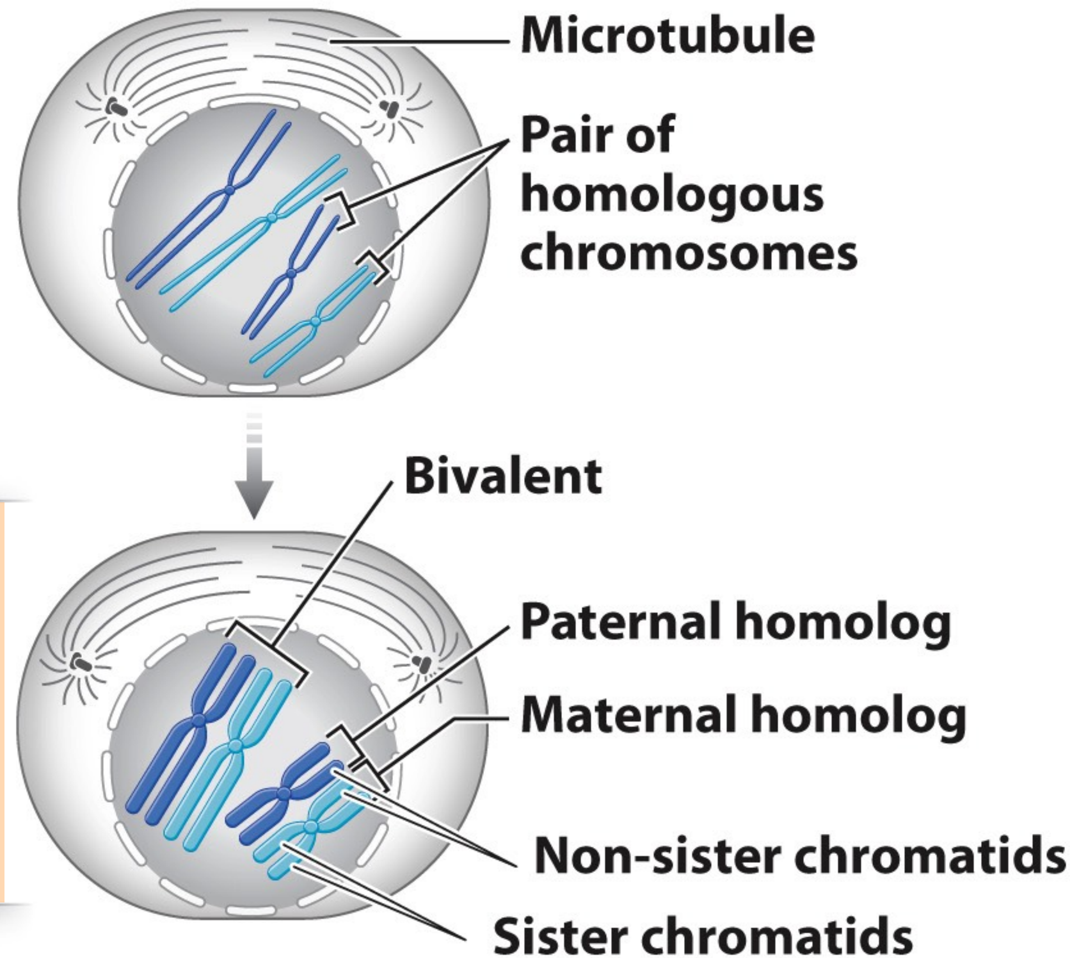
1 Chromosomes first become visible as thin threads. DNA replication is already complete.

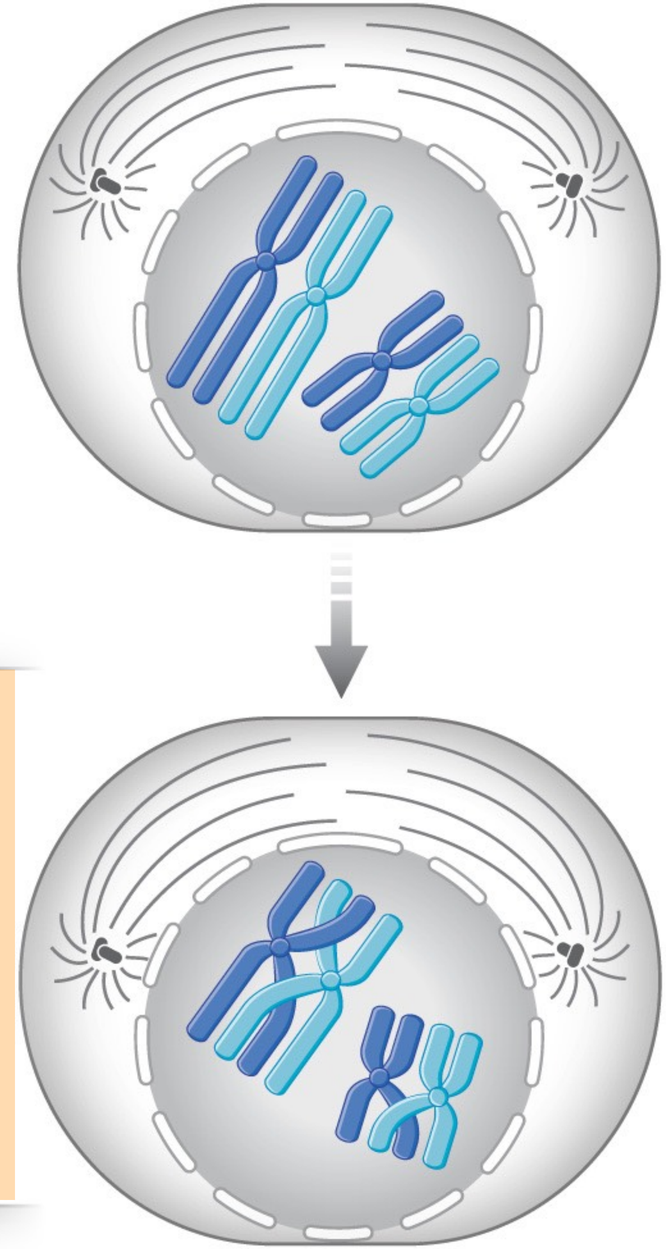


2 Homologous chromosomes continue to condense and undergo synapsis (gene-for-gene pairing).



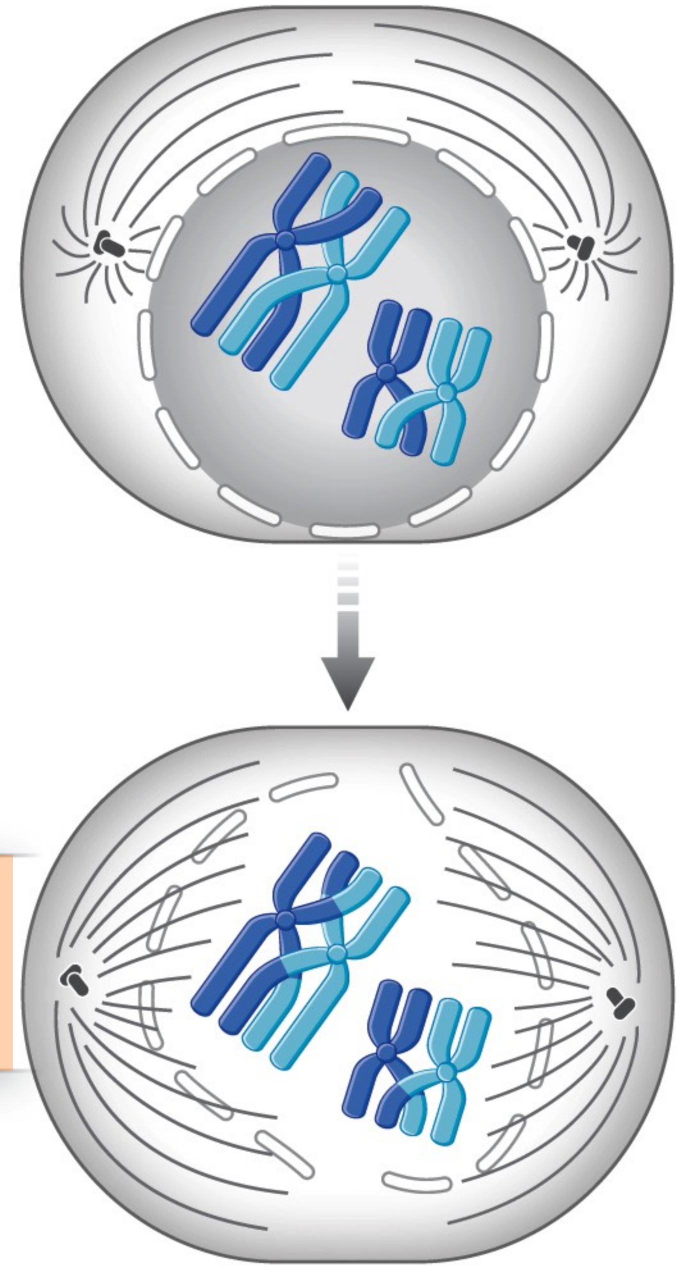
3 When synapsis is complete, each pair of homologous chromosomes forms a bivalent. Each chromosome consists of two sister chromatids.





4

**The chromosomes continue to shorten and thicken and the chiasmata between non-sister chromatids become apparent.**

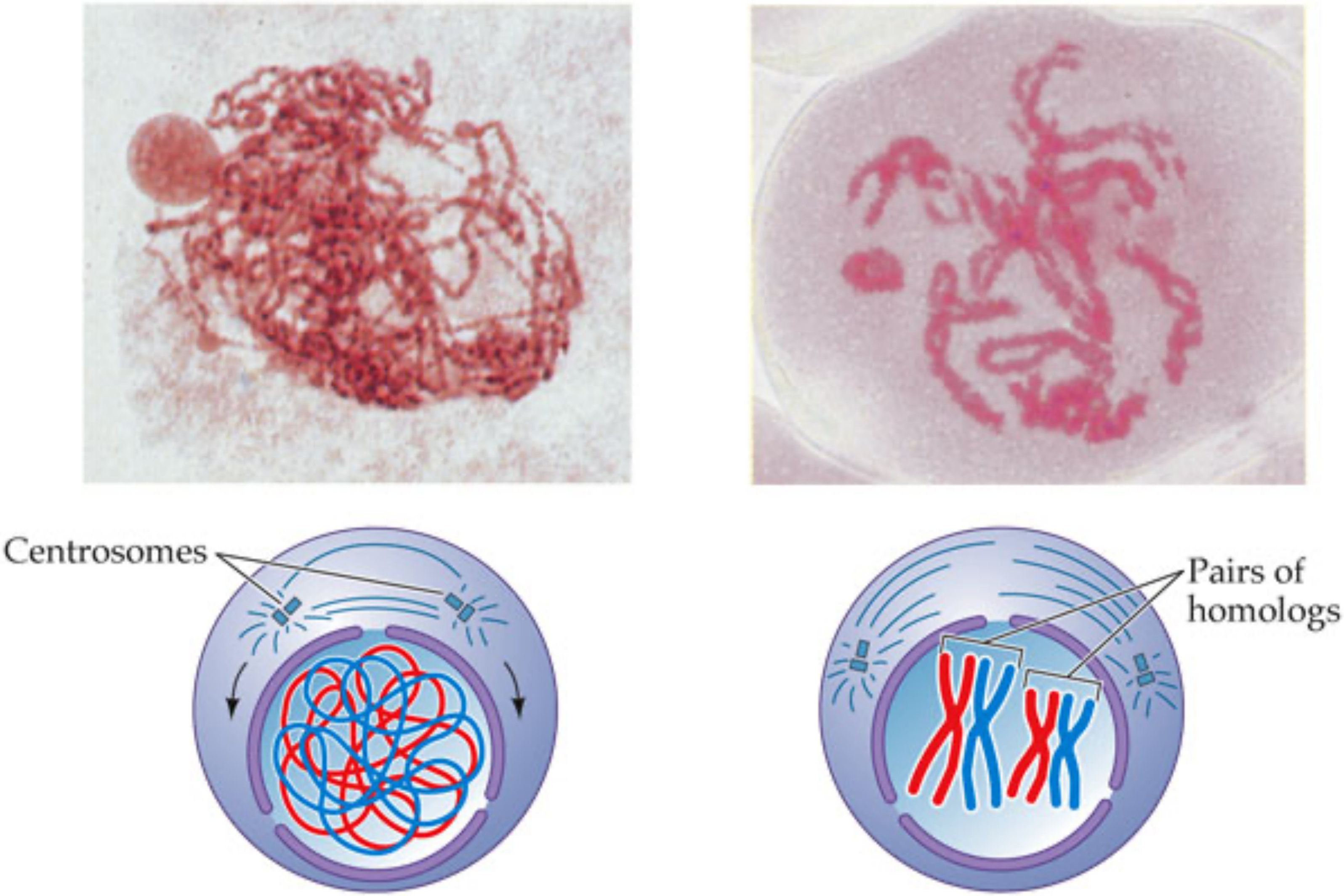


**5** **The nuclear envelope begins to break down.**

# MEIOSIS I

## Early Prophase I

## Mid-Prophase I




*LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition*, **Figure 9.14 Meiosis (Part 1)**

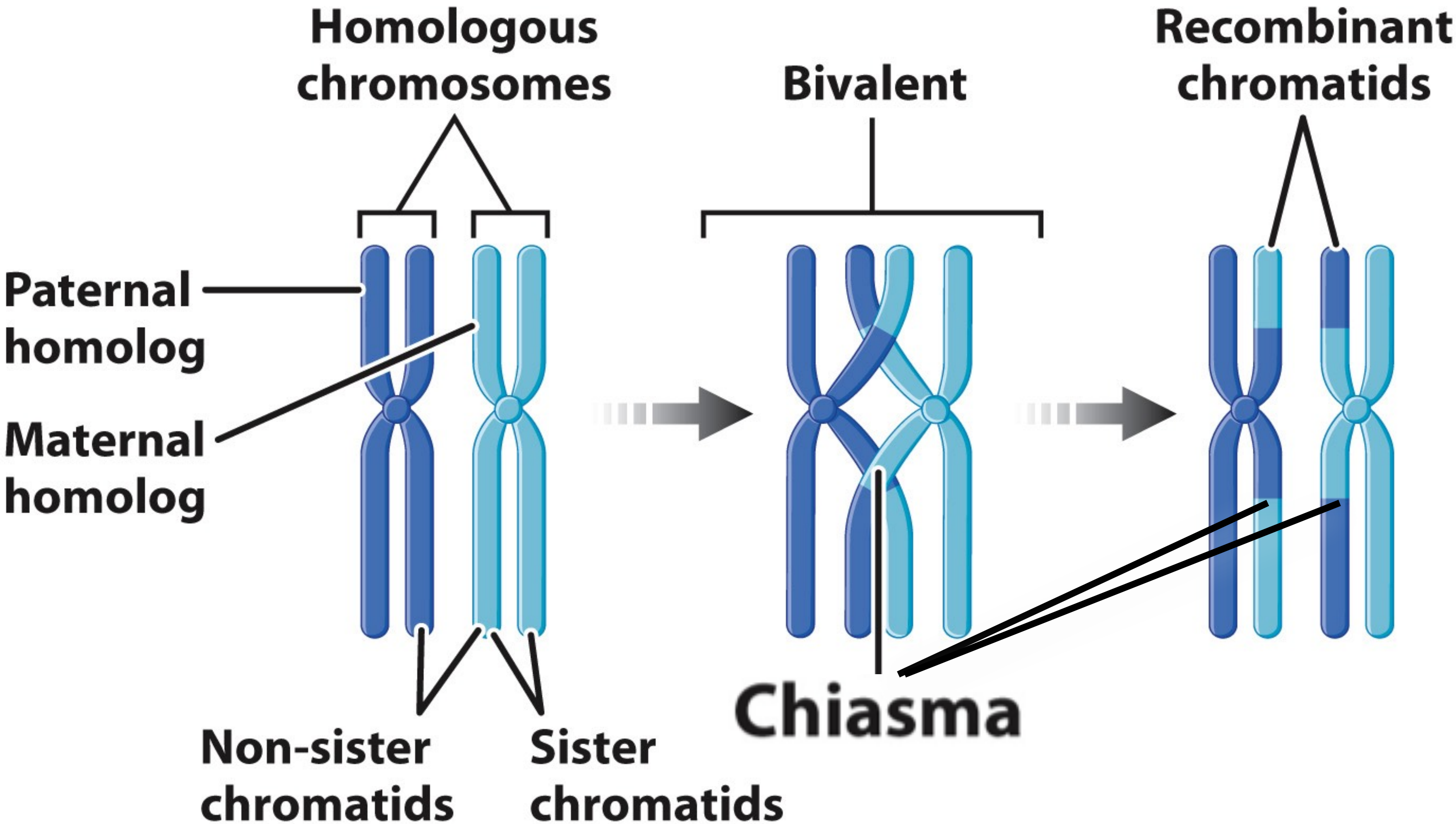
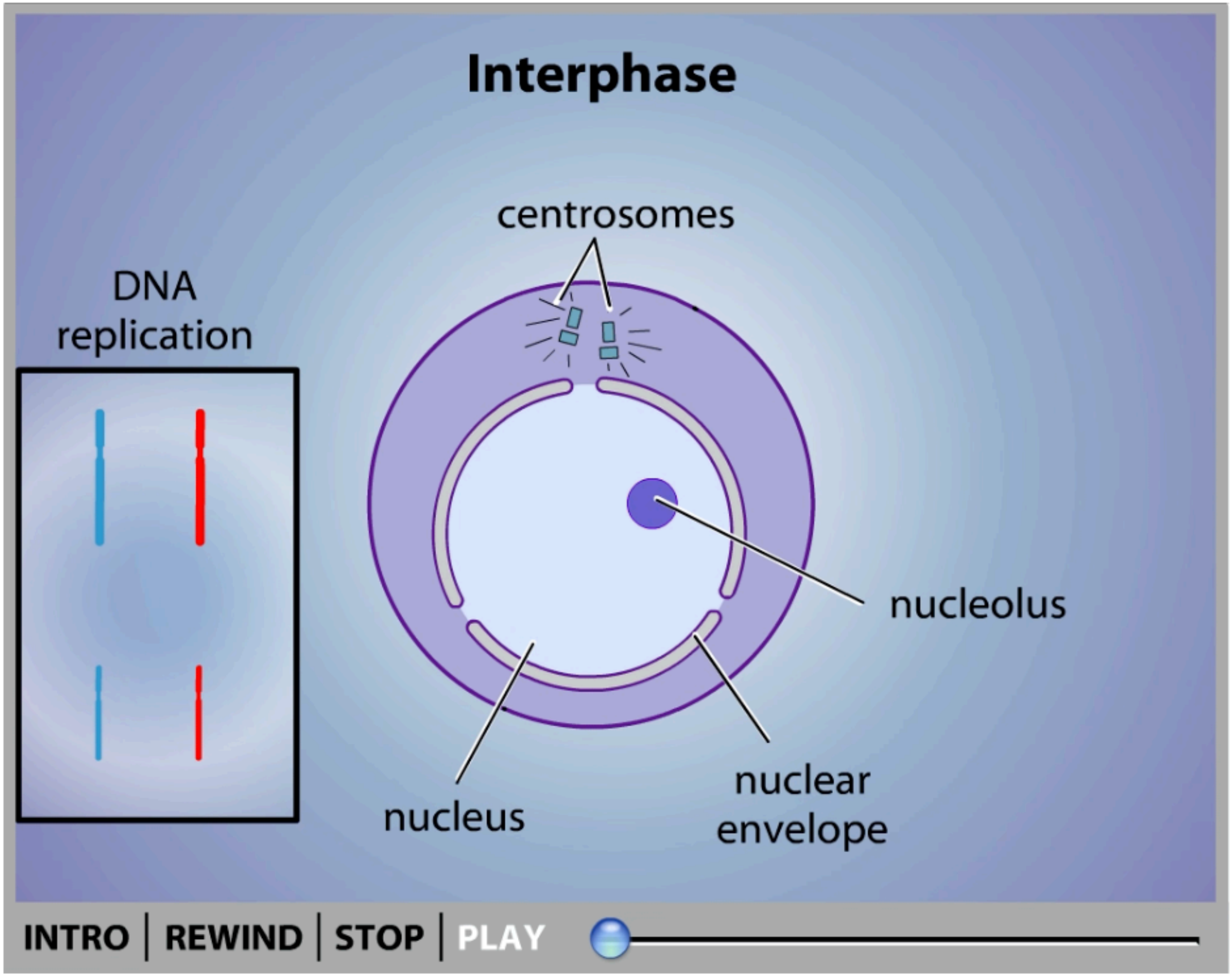



**Figure 11.9**
*Biology: How Life Works*, Second Edition


Interphase
centrosomes
DNA replication
nucleolus
nucleus
nuclear envelope
INTRO
REWIND
STOP
PLAY

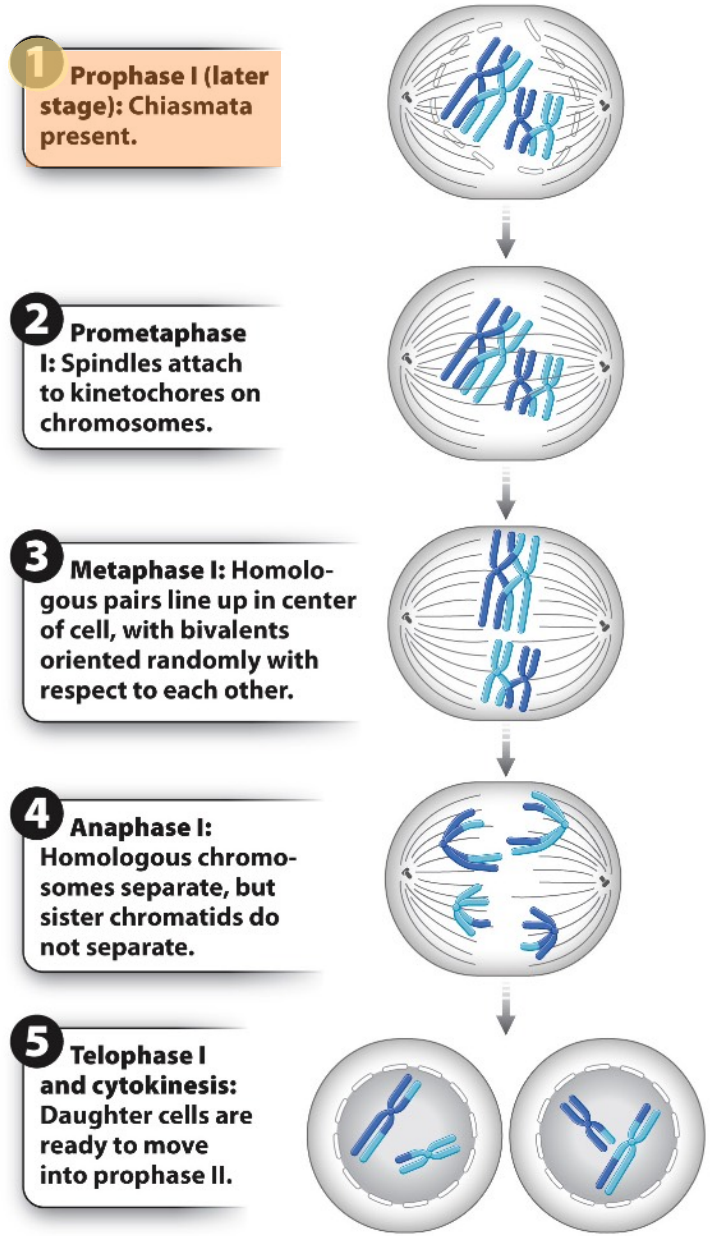
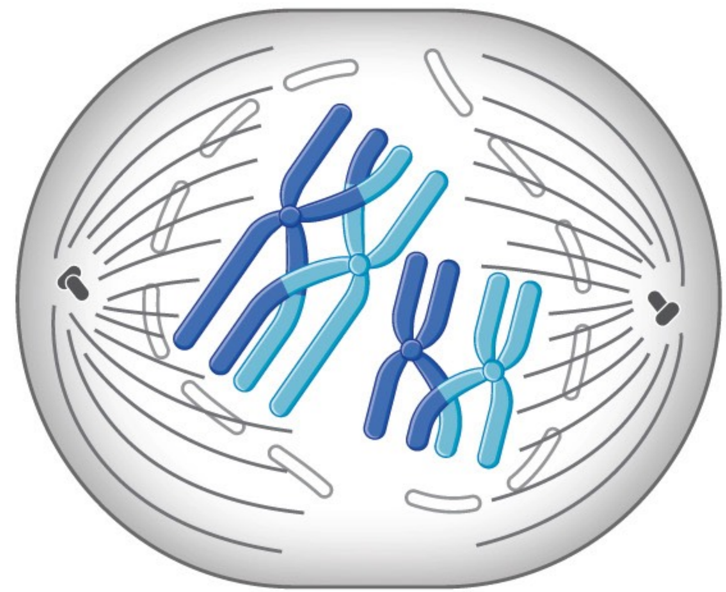



**Figure 11.10**

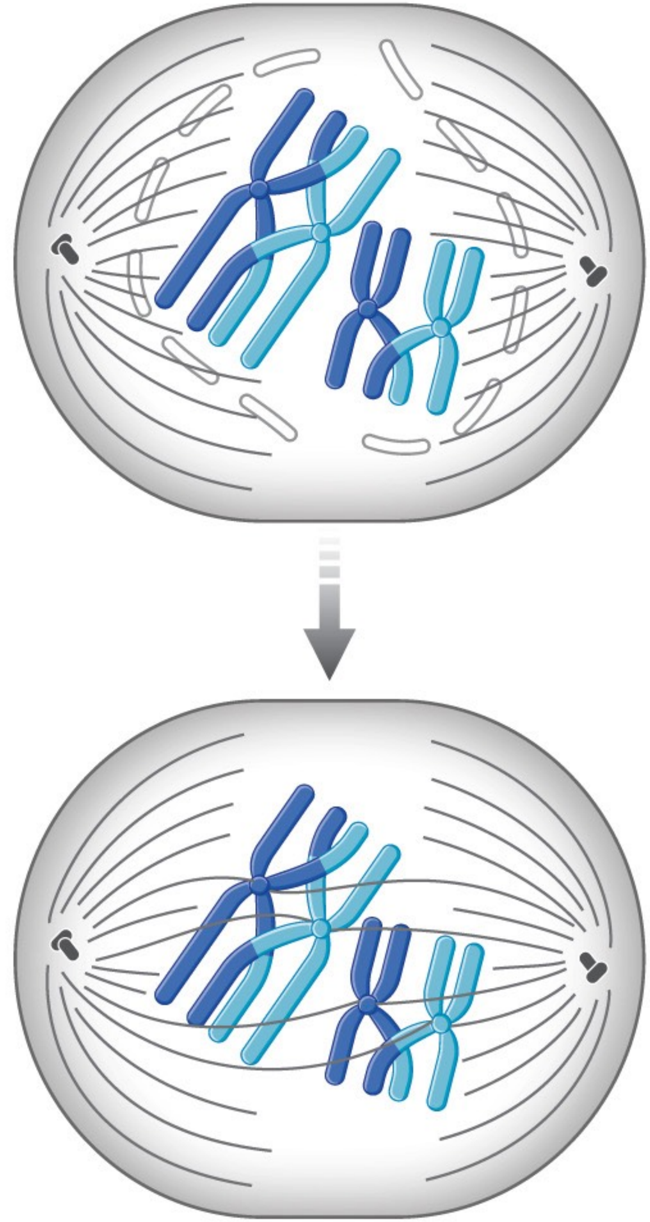
*Biology: How Life Works*, Second Edition

1 Prophase I (later stage): Chiasmata present.

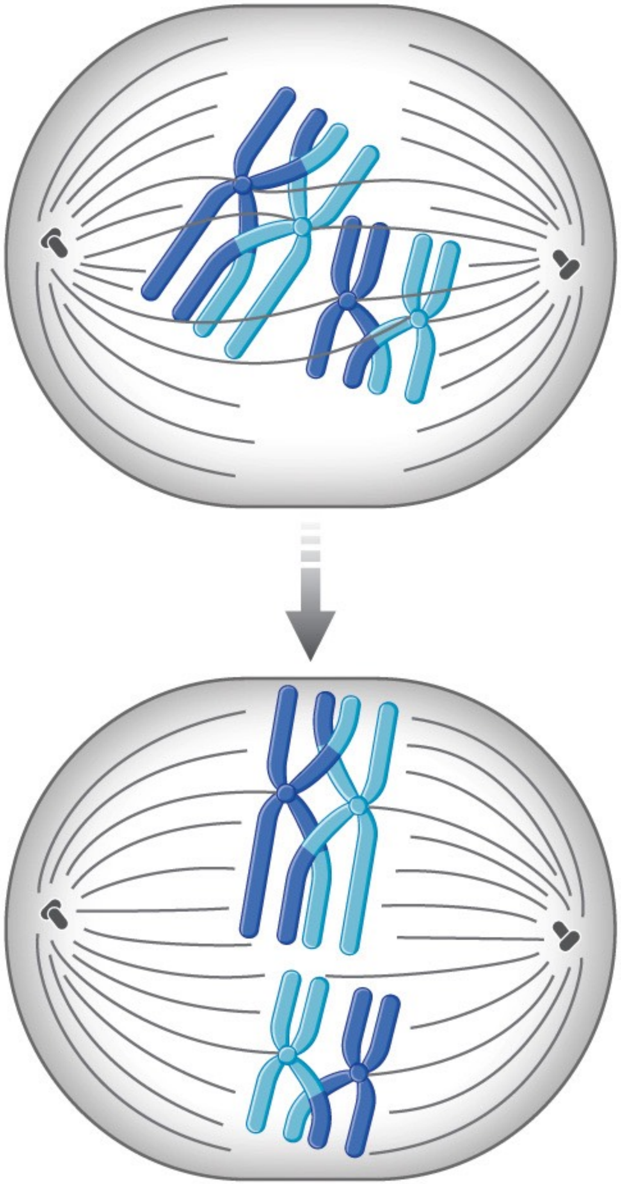


2

**Prometaphase I: Spindles attach to kinetochores on chromosomes.**



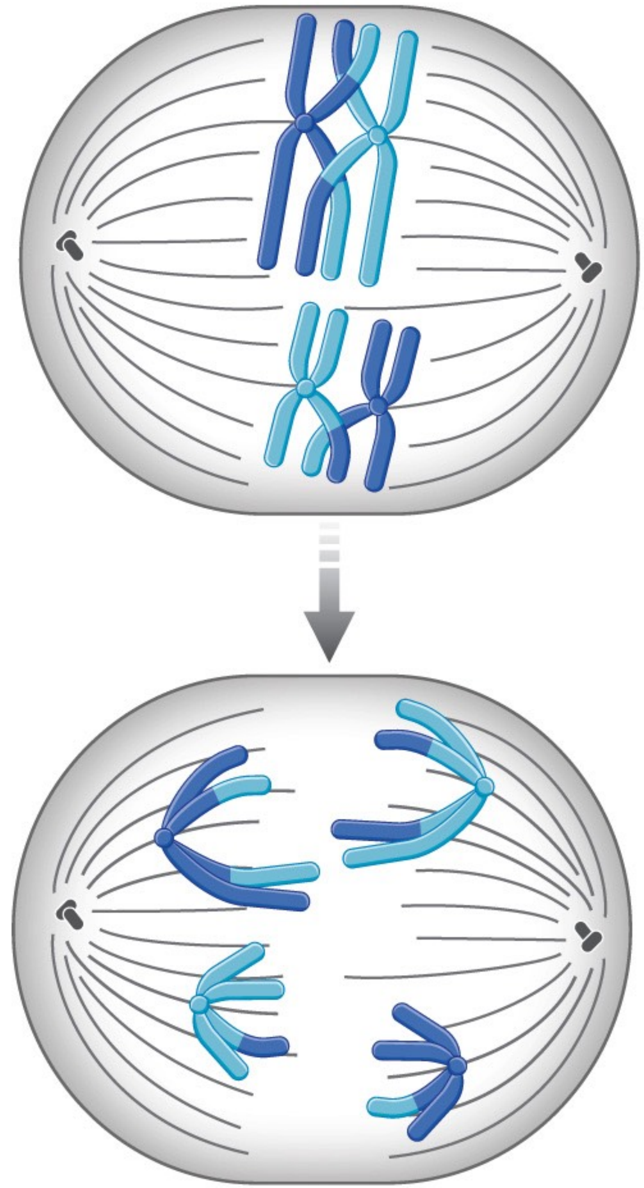
“two by two”



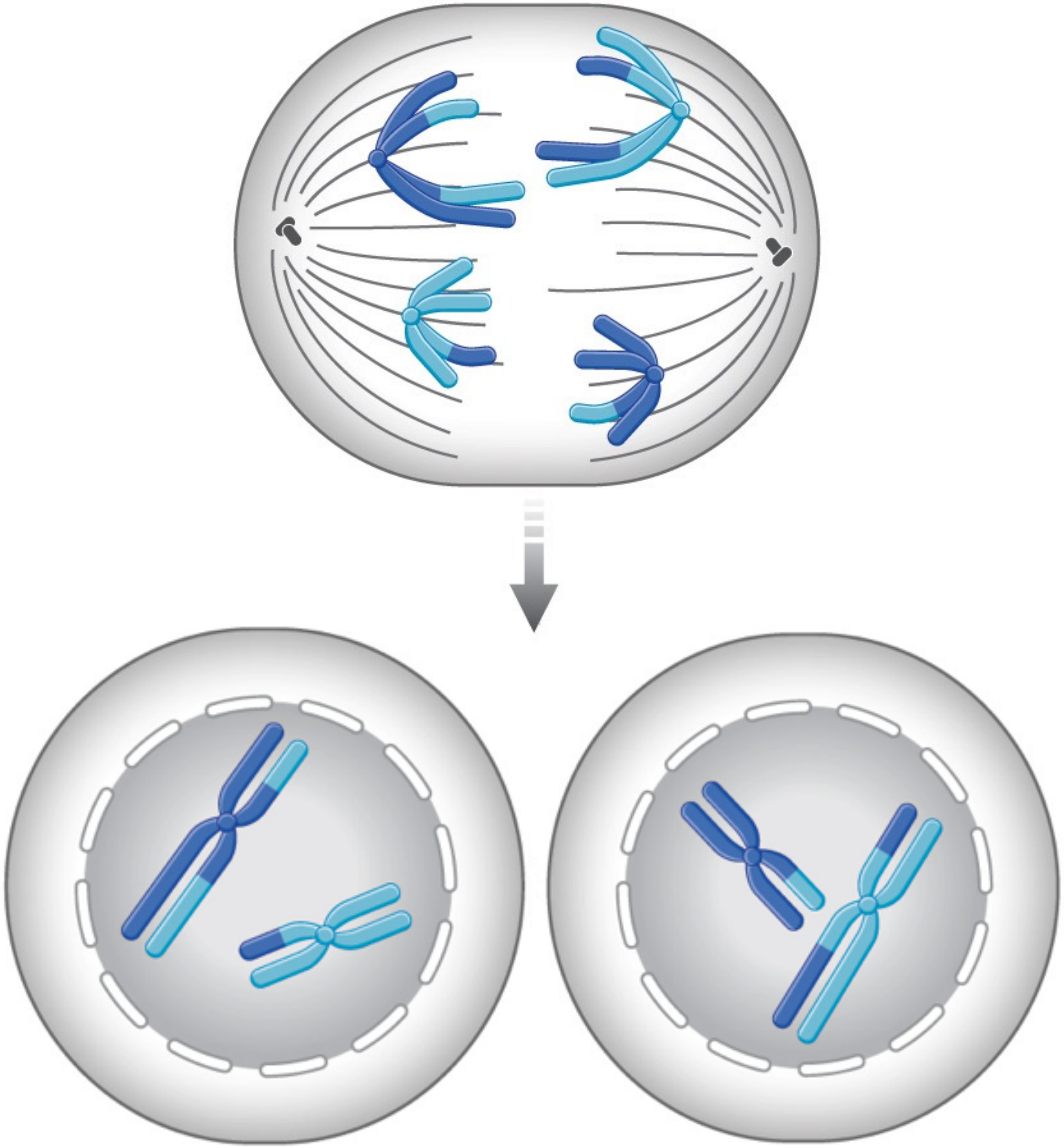
3

**Metaphase I: Homologous pairs line up in center of cell, with bivalents oriented randomly with respect to each other.**

4 **Anaphase I:** Homologous chromosomes separate, but sister chromatids do not separate.



5 **Telophase I and cytokinesis:** Daughter cells are ready to move into prophase II.



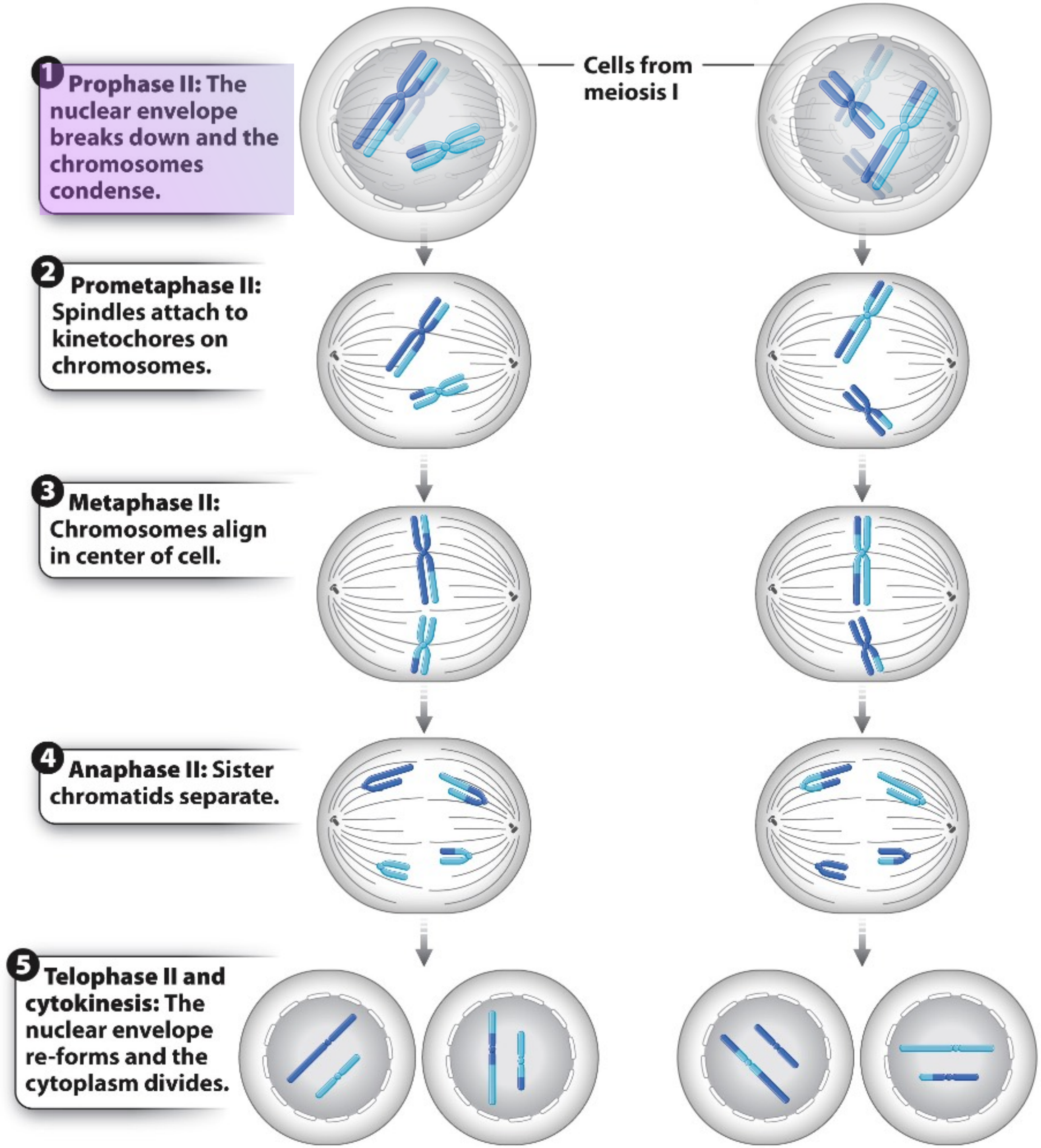
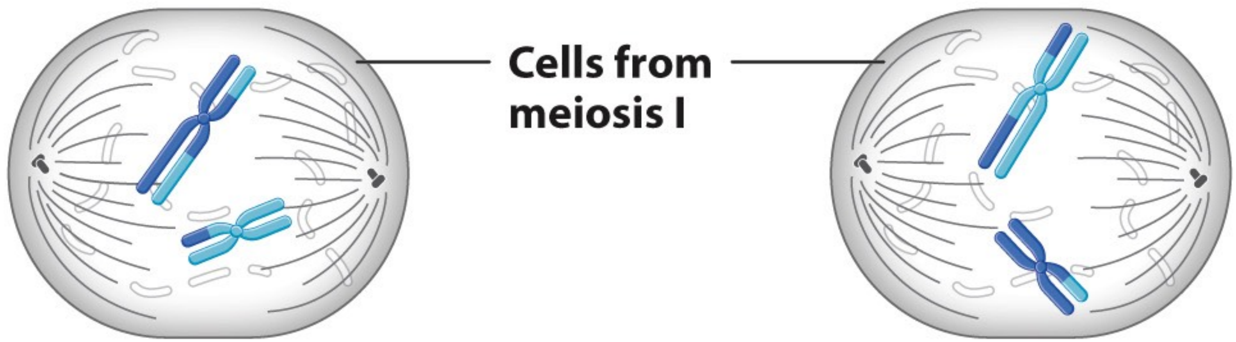
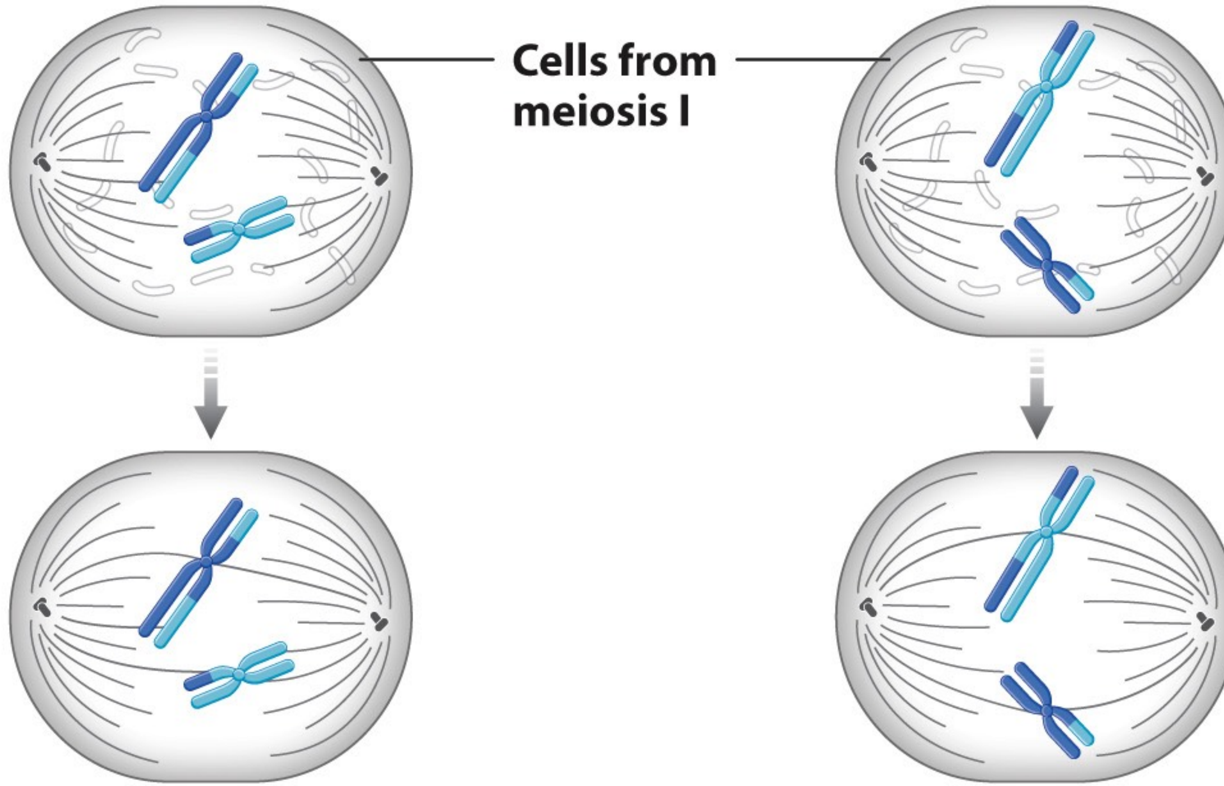



**Figure 11.11**
*Biology: How Life Works*, Second Edition

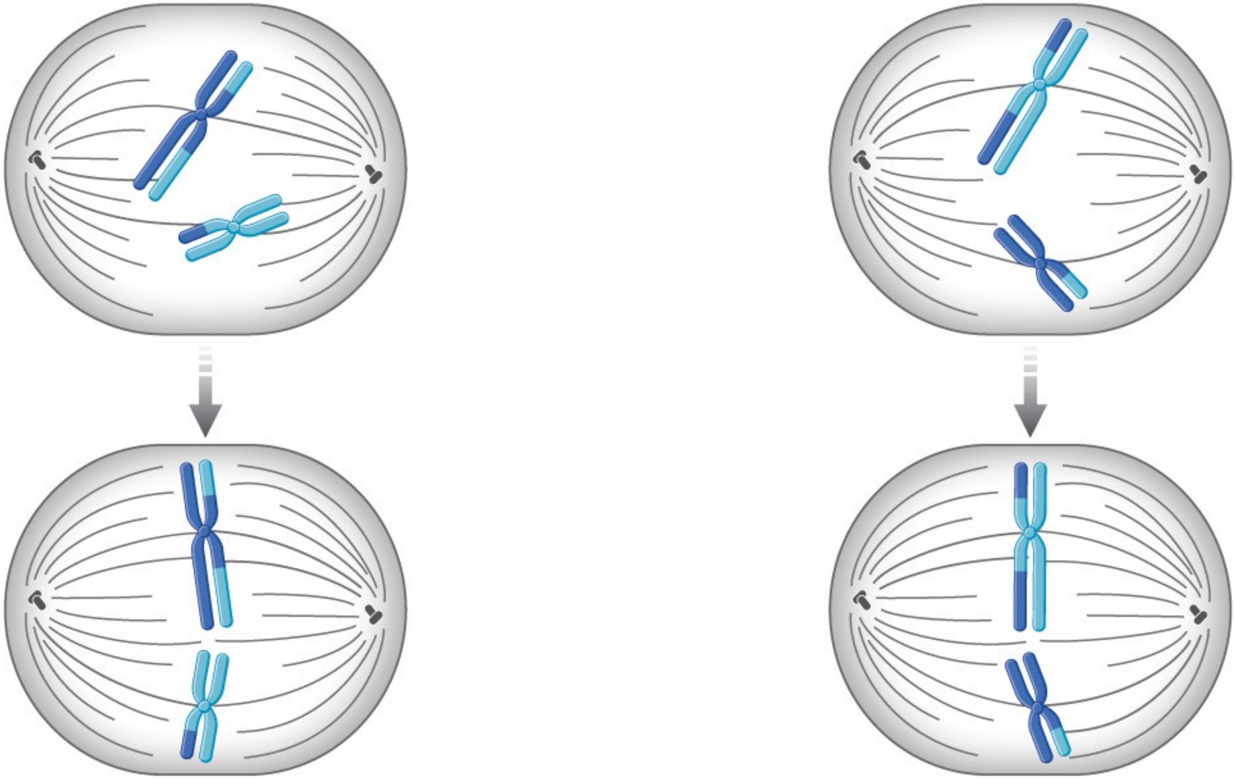
1 **Prophase II: The nuclear envelope breaks down and the chromosomes condense.**



**2 Prometaphase II: Spindles attach to kinetochores on chromosomes.**

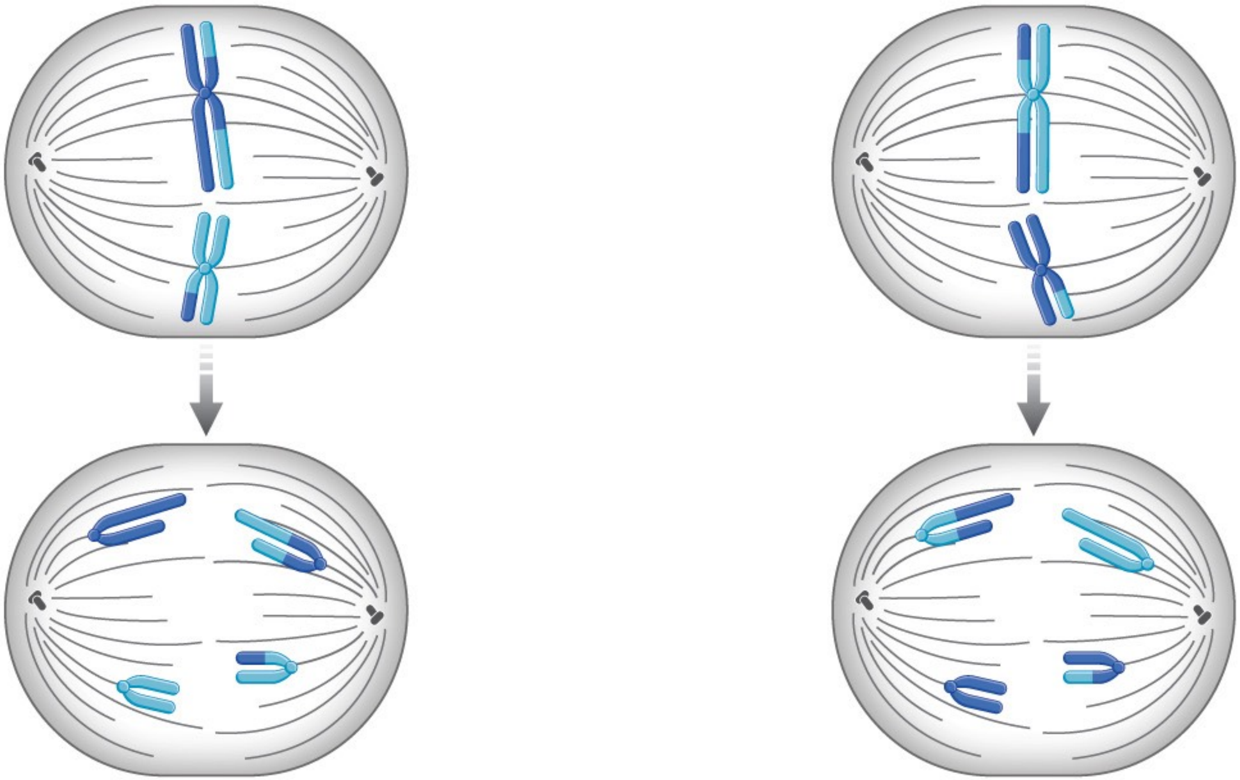


**Metaphase II:**
**Chromosomes align in center of cell.**

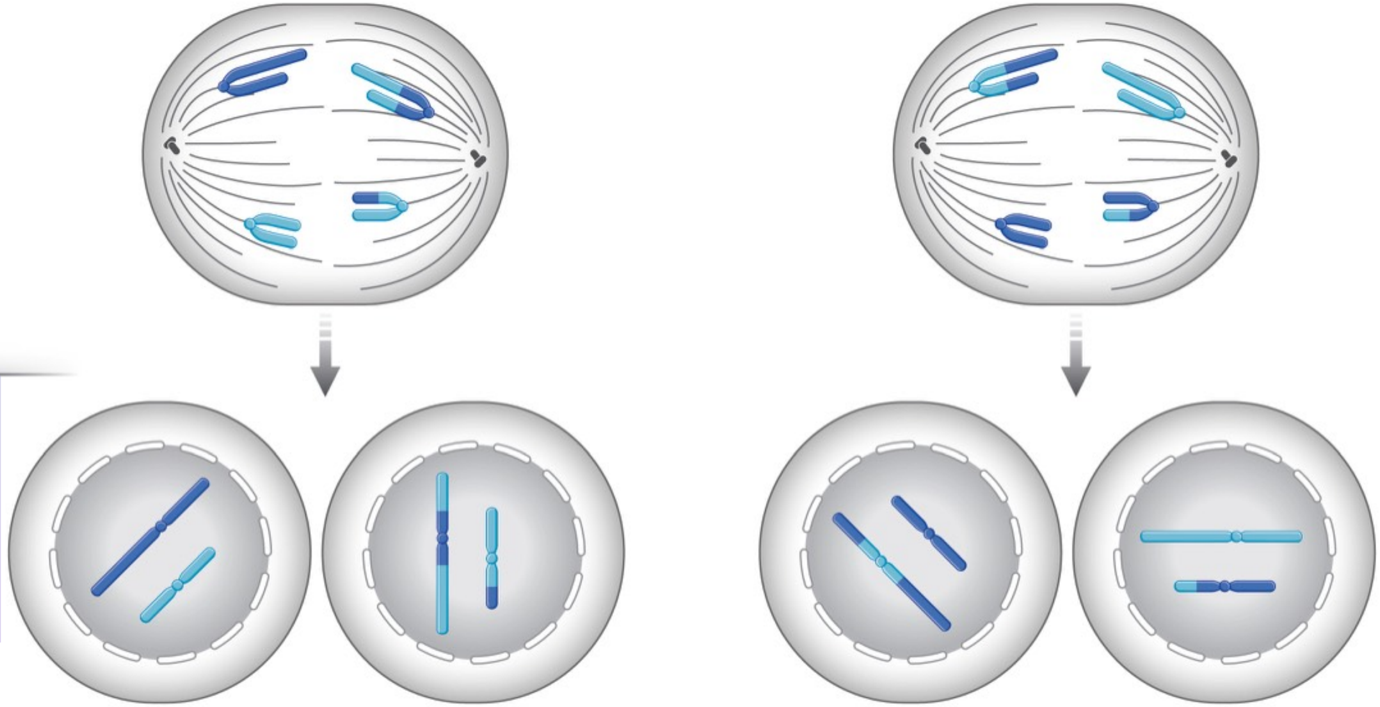


“single file”

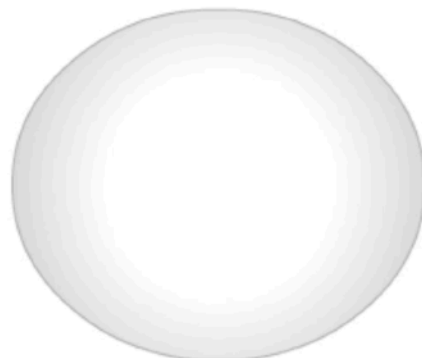
**4 Anaphase II: Sister chromatids separate.**



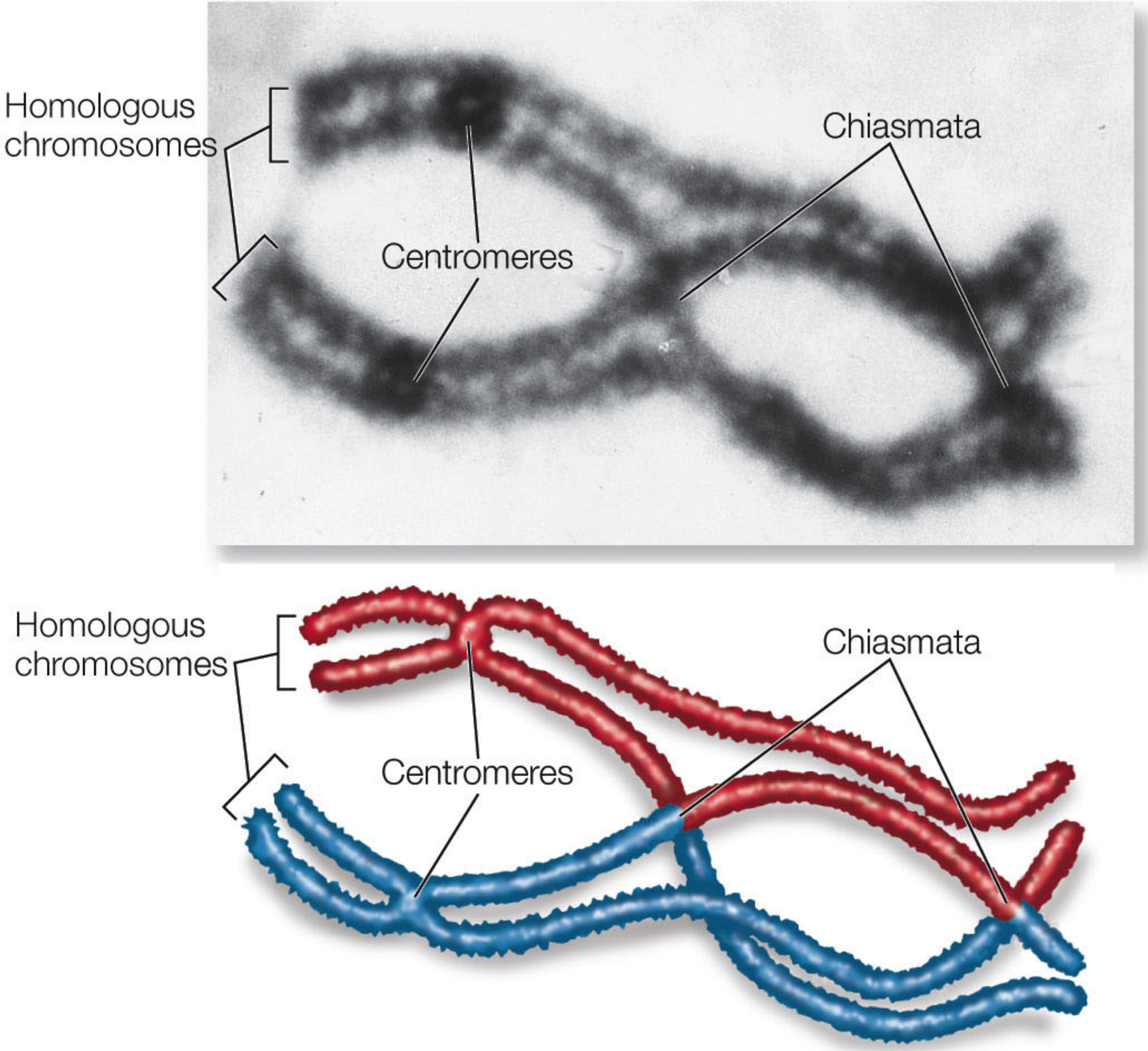
**5 Telophase II and cytokinesis: The nuclear envelope re-forms and the cytoplasm divides.**



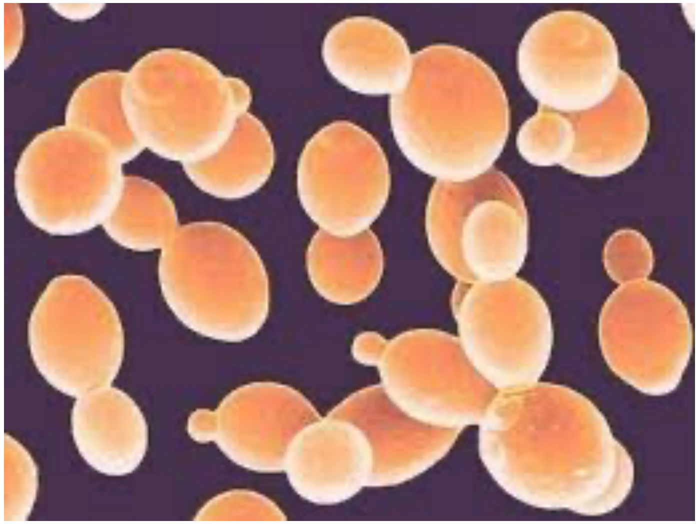
# Meiotic Cell Division



In meiotic cell division, a diploid cell divides into four haploid cells, each of which is genetically unique. It consists of two rounds of cell division, called meiosis I and meiosis II.




***LIFE 8e*, Figure 9.17**

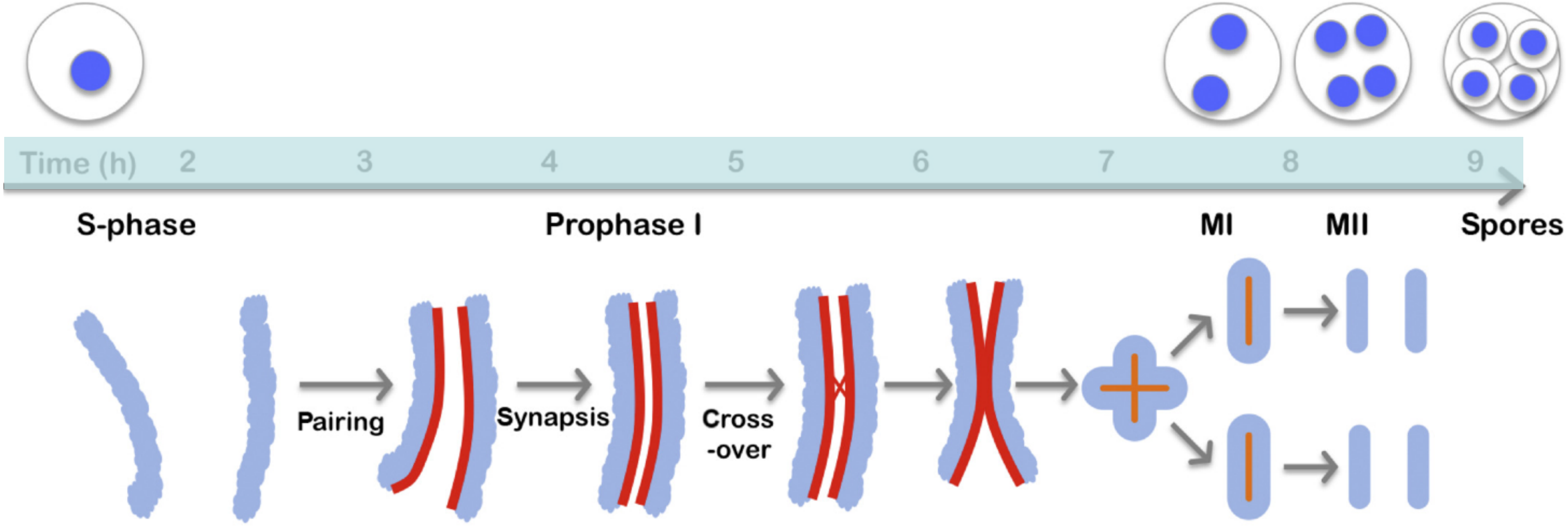


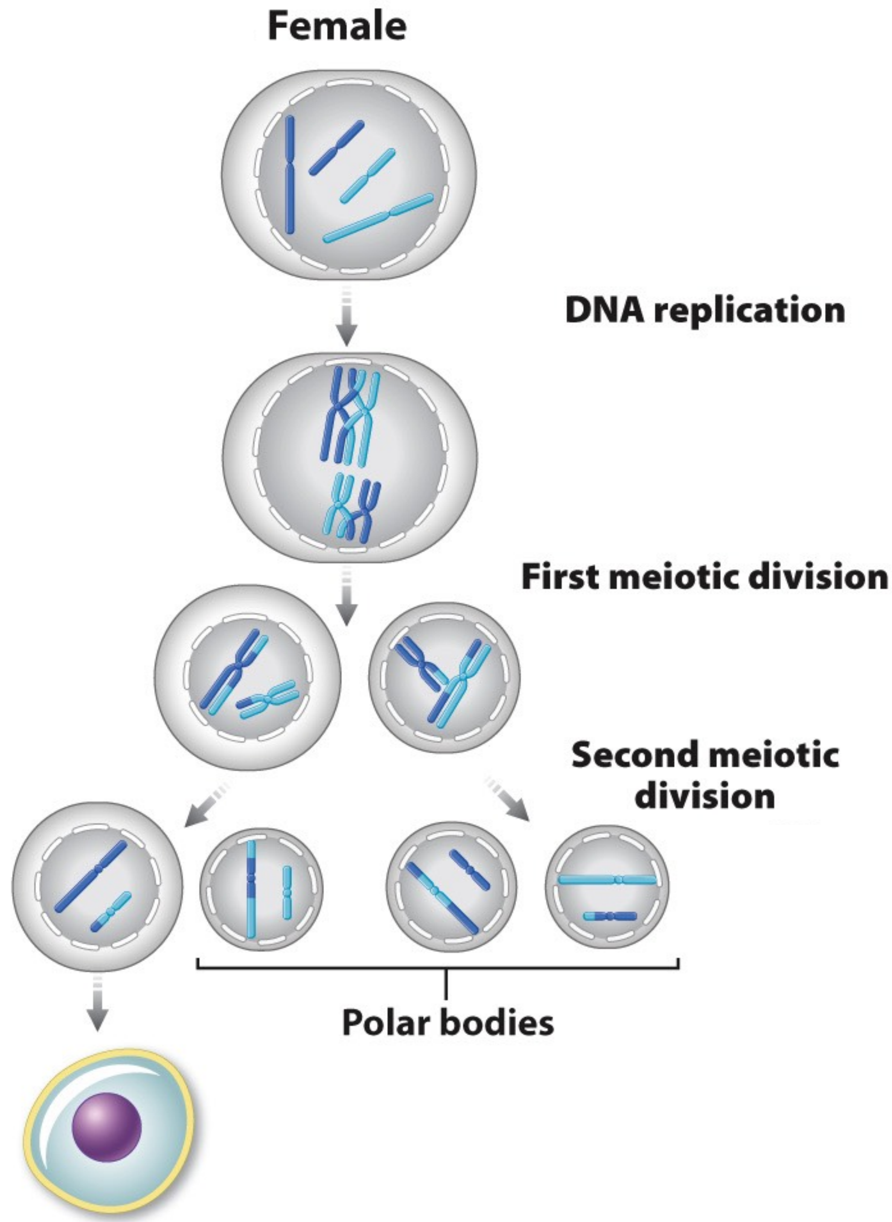
Budding Yeast

*S. cerevisiae*

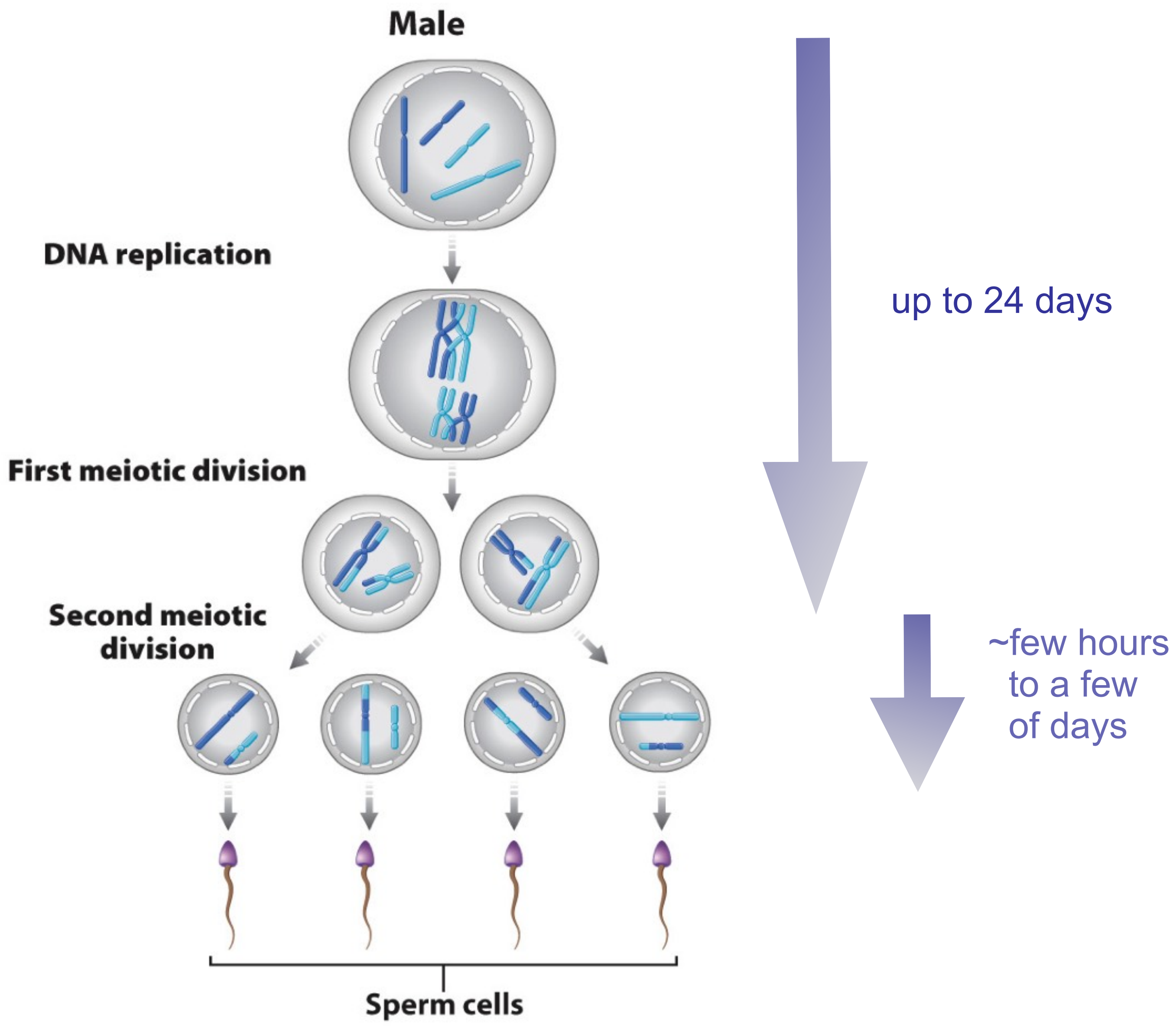
*~90 min doubling time (haploid)*

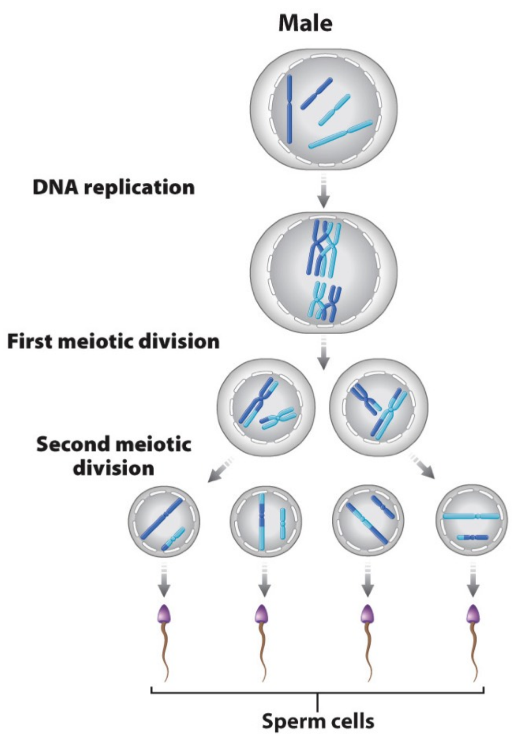
*Mitosis*

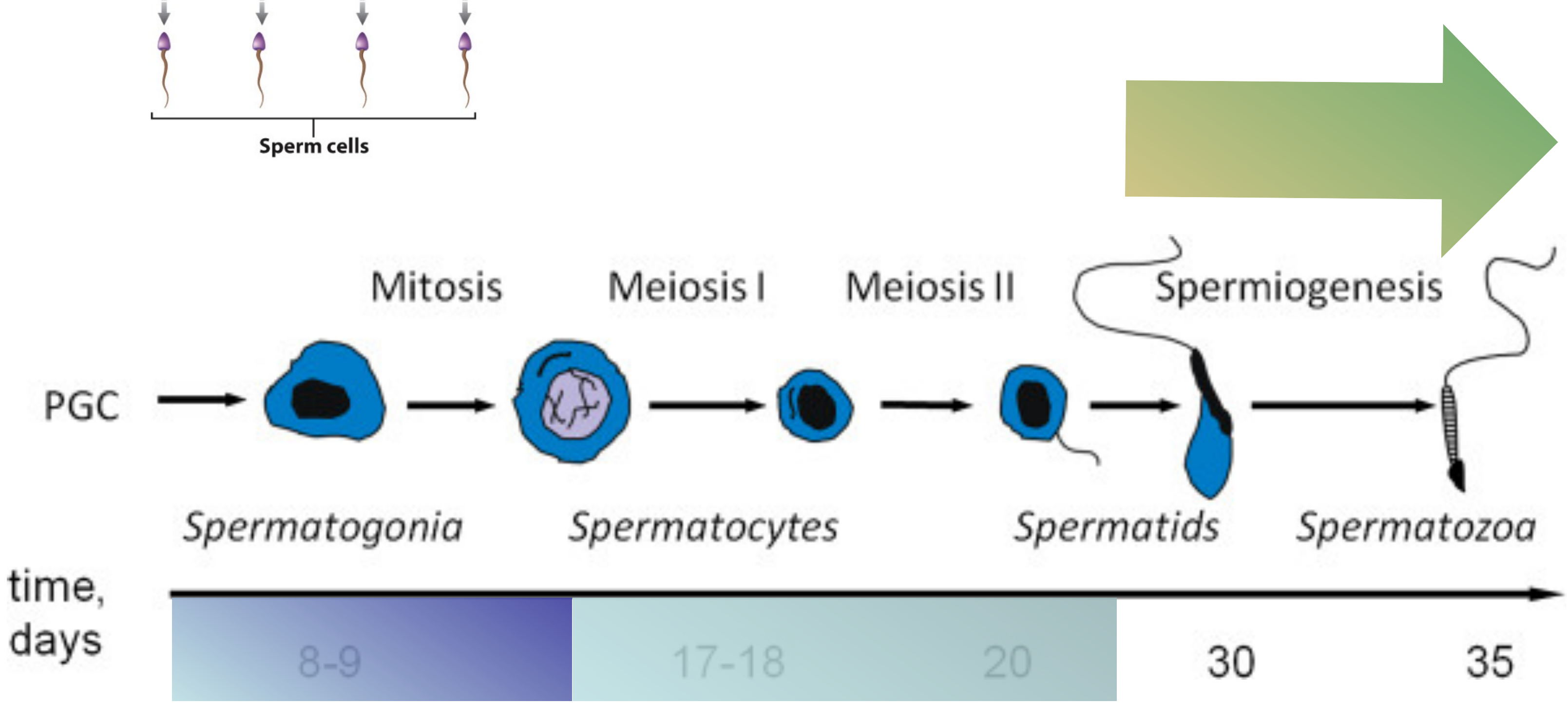




Female
DNA replication
First meiotic division
Second meiotic division
Polar bodies

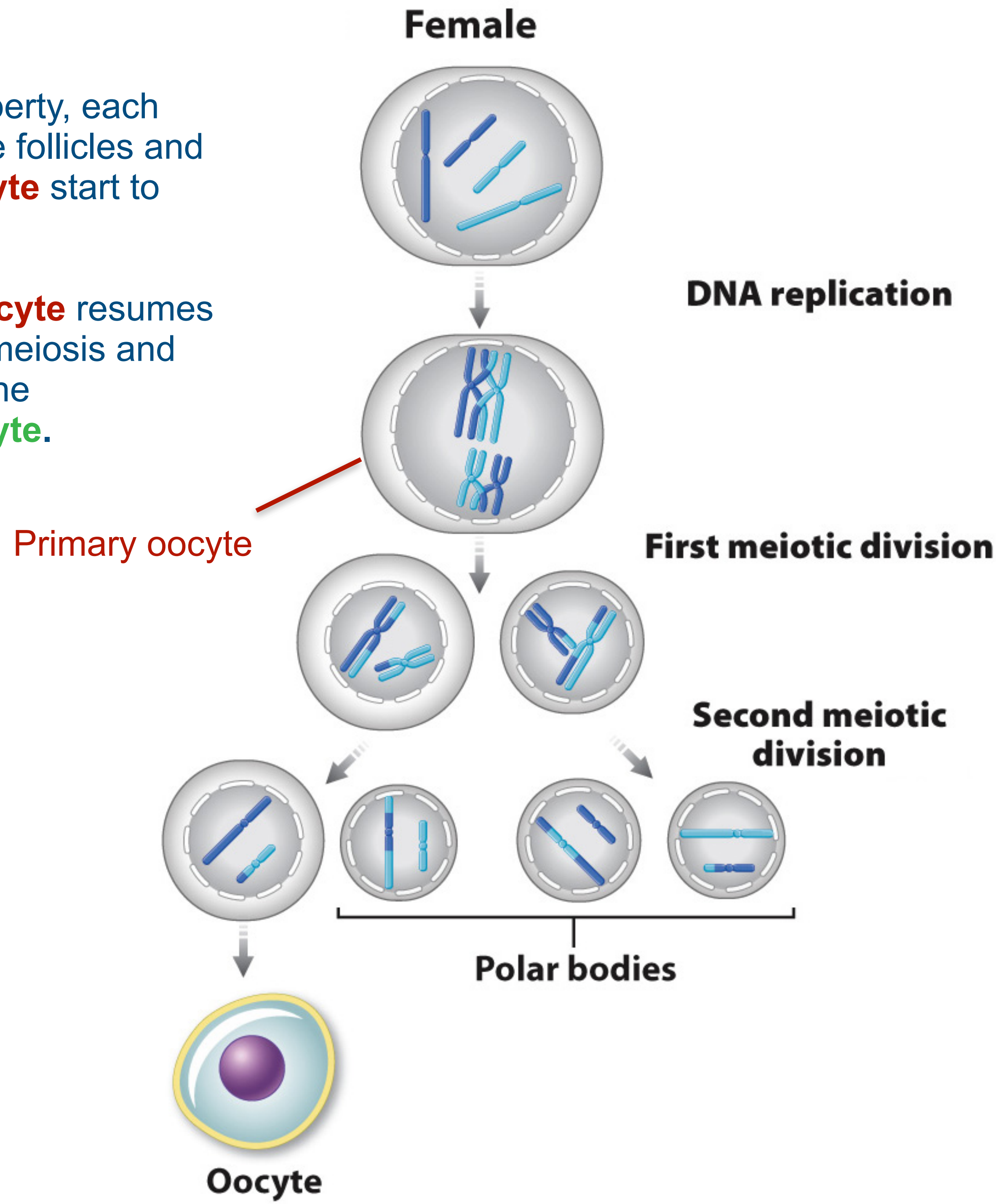

Male
DNA replication
First meiotic division
Second meiotic division
Sperm cells
up to 24 days
~few hours to a few of days


Male
DNA replication
First meiotic division
Second meiotic division
Sperm cells


Mitosis
Meiosis I
Meiosis II
Spermiogenesis
PGC
Spermatogonia
Spermatocytes
Spermatids
Spermatozoa
time, days
8-9
17-18
20
30
35

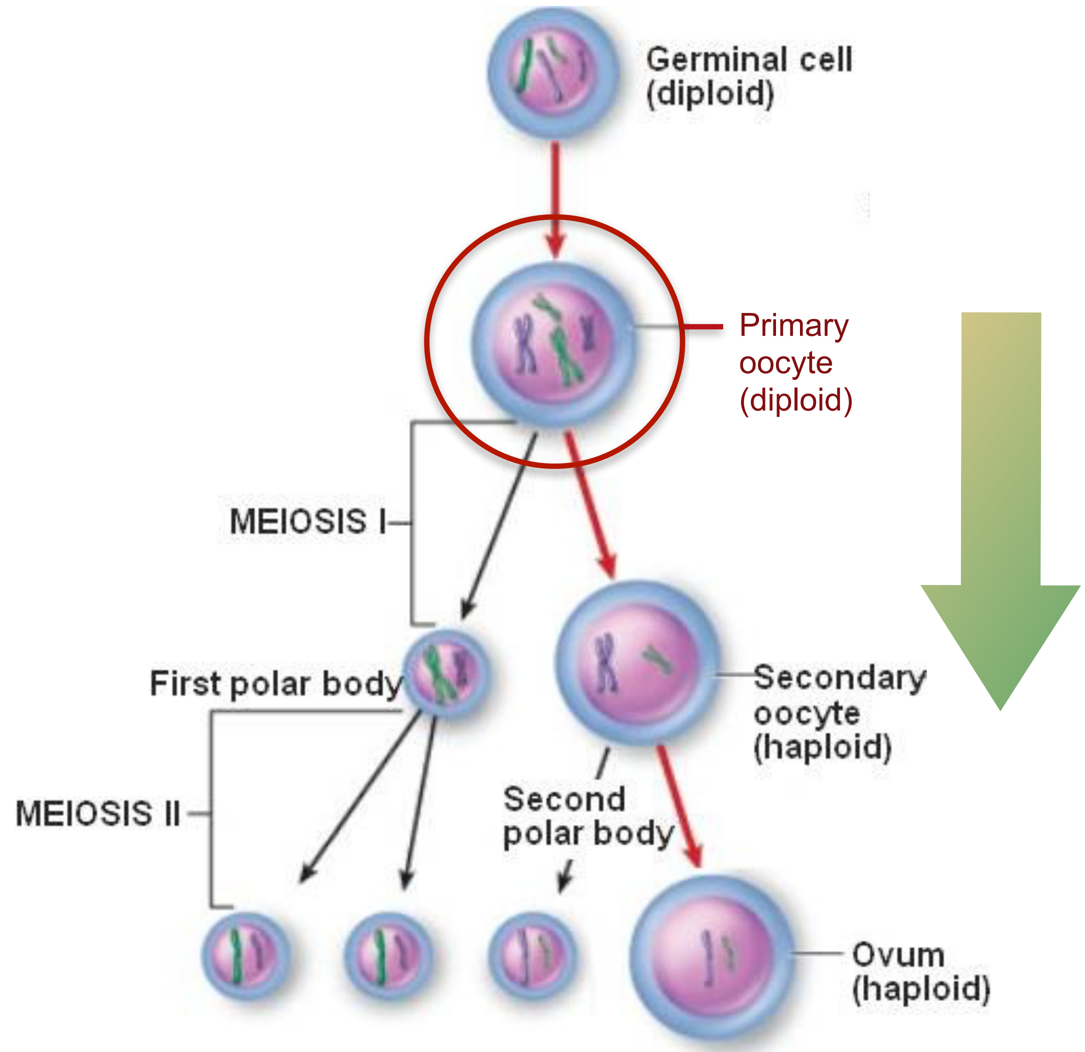
Beginning in puberty, each month one of the follicles and its **primary oocyte** start to mature…

The **primary oocyte** resumes metaphase I of meiosis and divides to form the **secondary oocyte.**



Beginning in puberty, each month one of the follicles and its **primary oocyte** start to mature.

The **primary oocyte** resumes meiosis and divides to form the **secondary oocyte.**

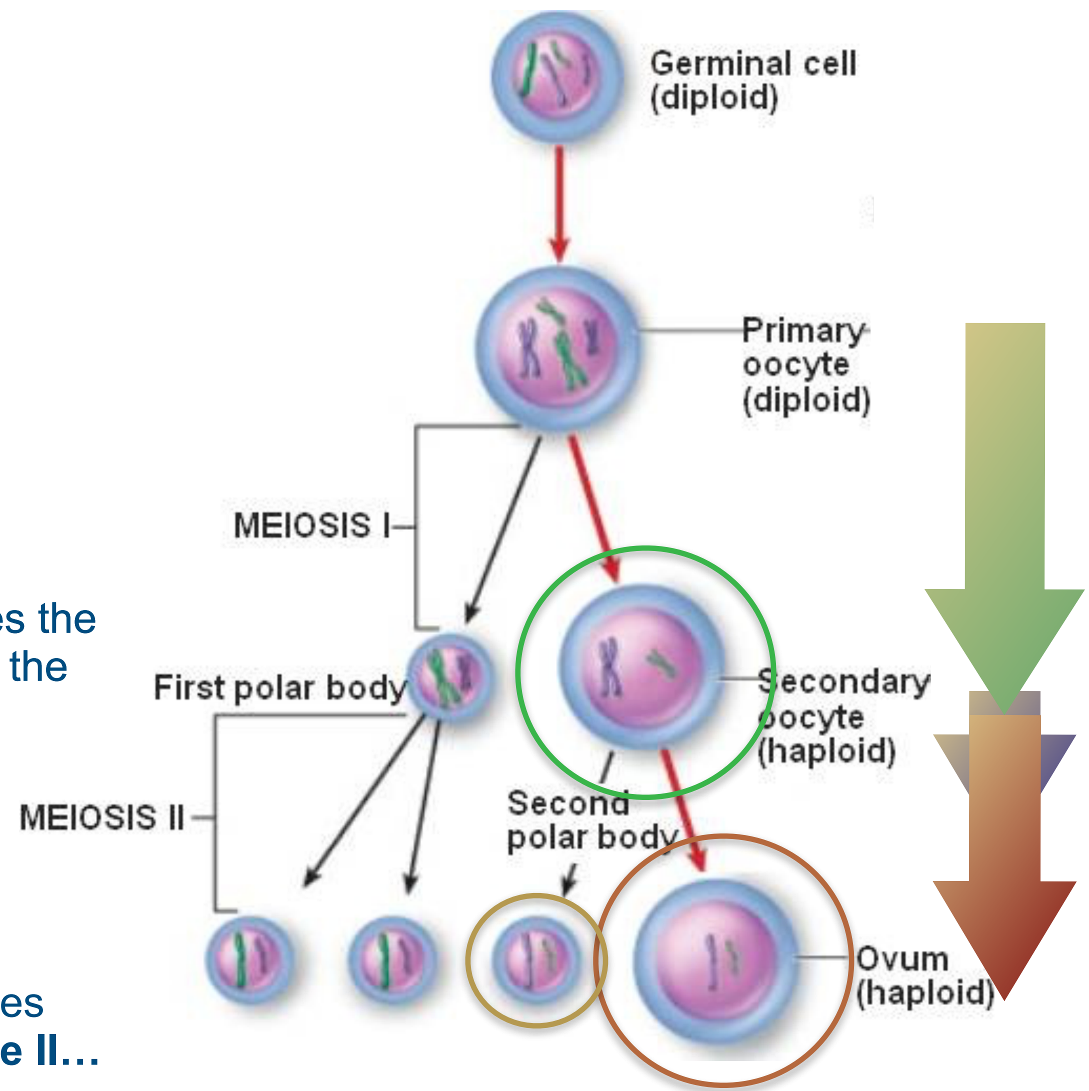


Beginning in puberty, each month one of the follicles and its **primary oocyte** start to mature.

The **primary oocyte** resumes meiosis and divides to form the **secondary oocyte.**

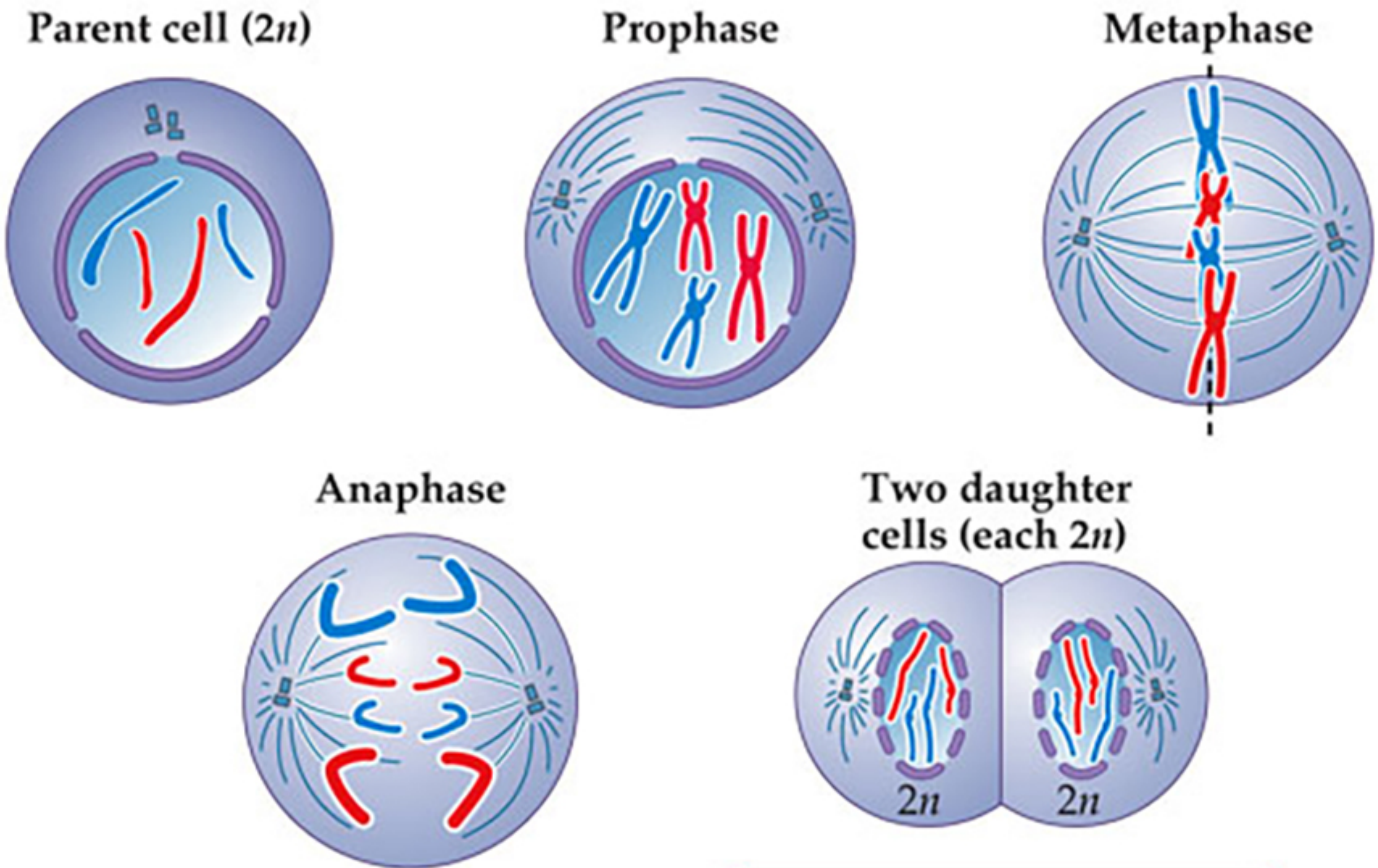
Once one of the daughter cells becomes the **secondary oocyte** the other cell forms the **first polar body**.

The **secondary oocyte** then commences **meiosis II**, which arrests at **metaphase II…**



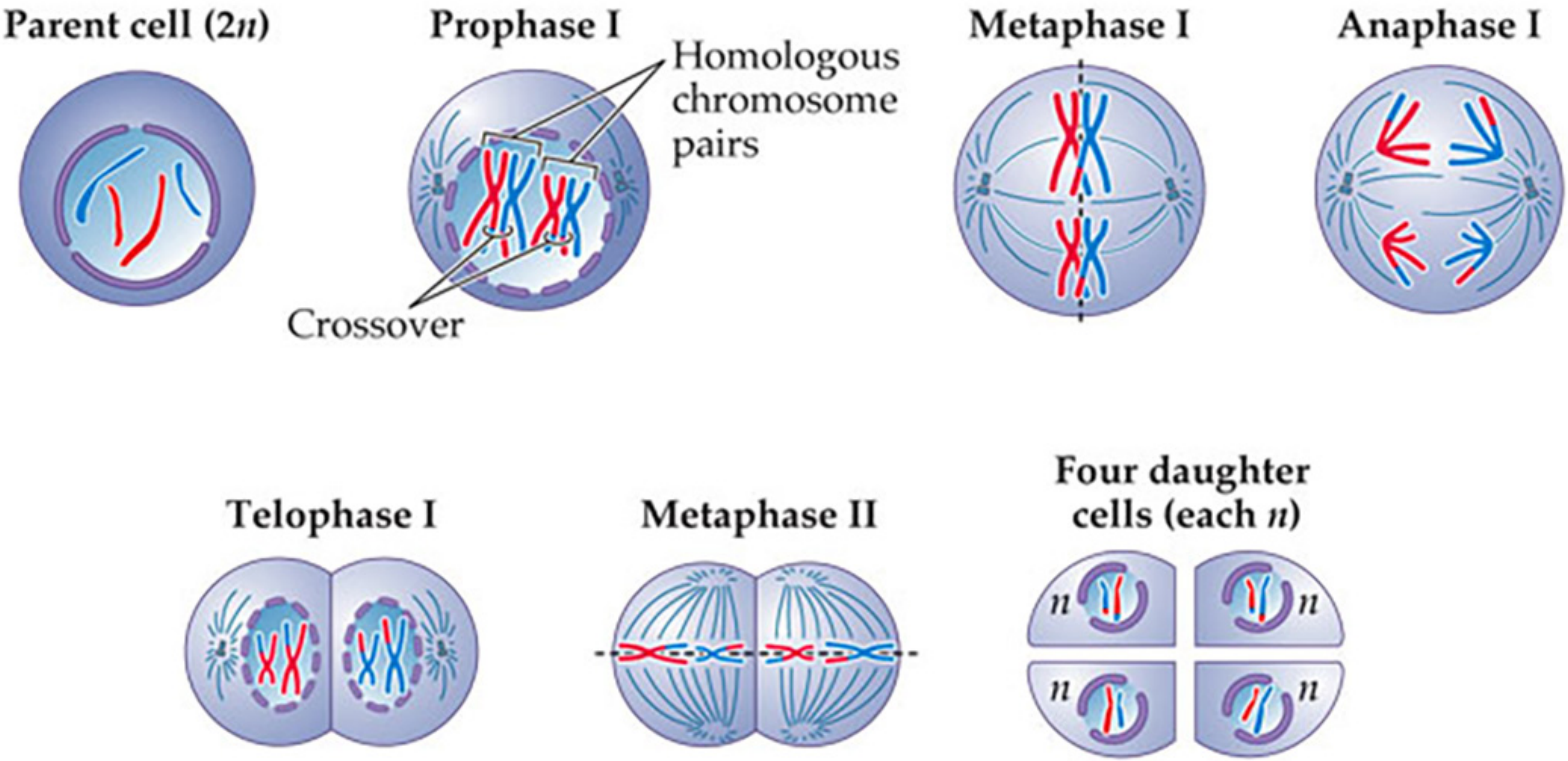

At fertilization **Meiosis II** completes - forming the **Ovum** and **second polar body**

# MITOSIS




Mitosis is a mechanism for constancy: The parent nucleus produces two identical daughter nuclei.

# MEIOSIS




**Meiosis is a mechanism for diversity: The parent nucleus produces four different haploid daughter nuclei.**

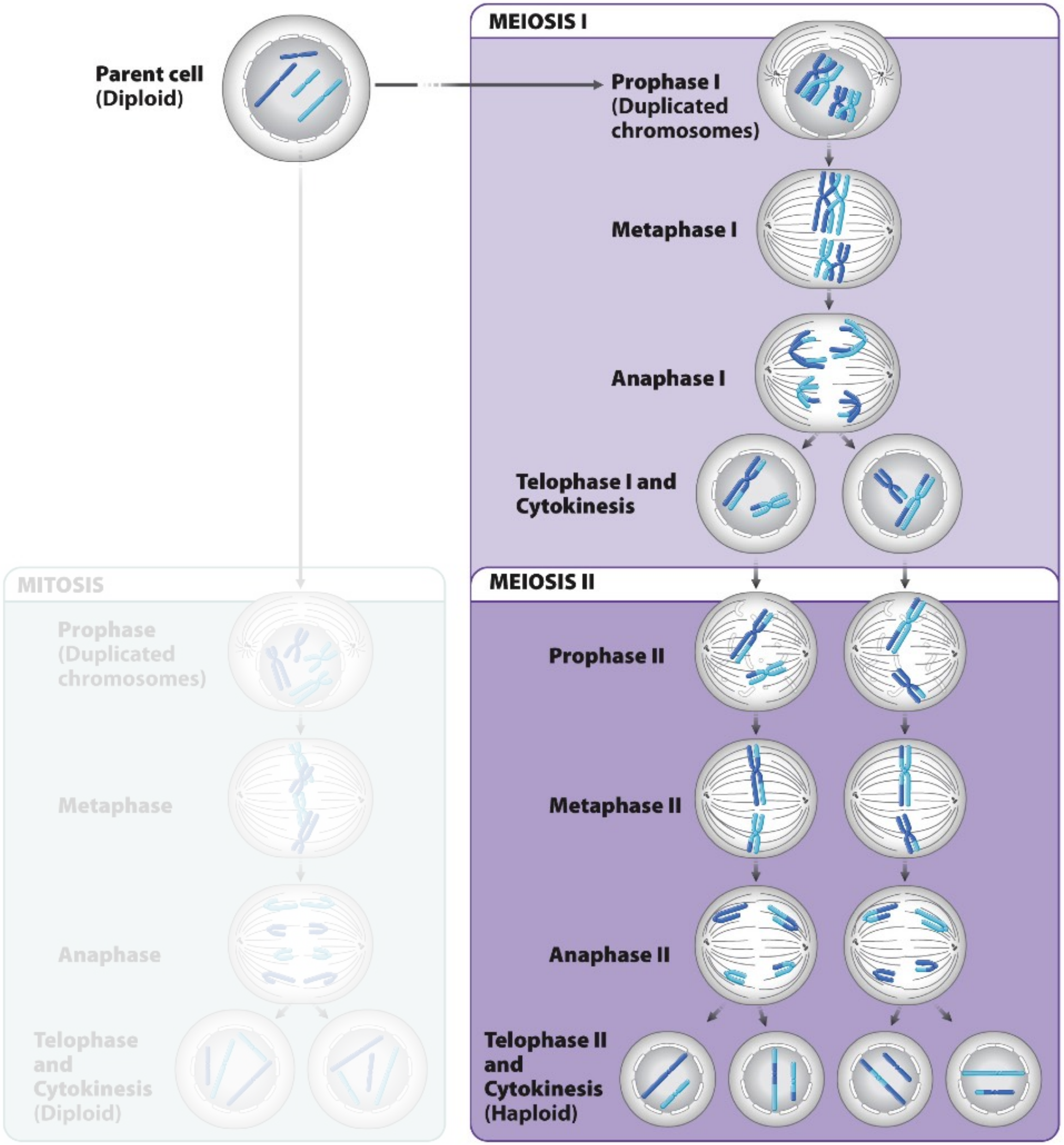


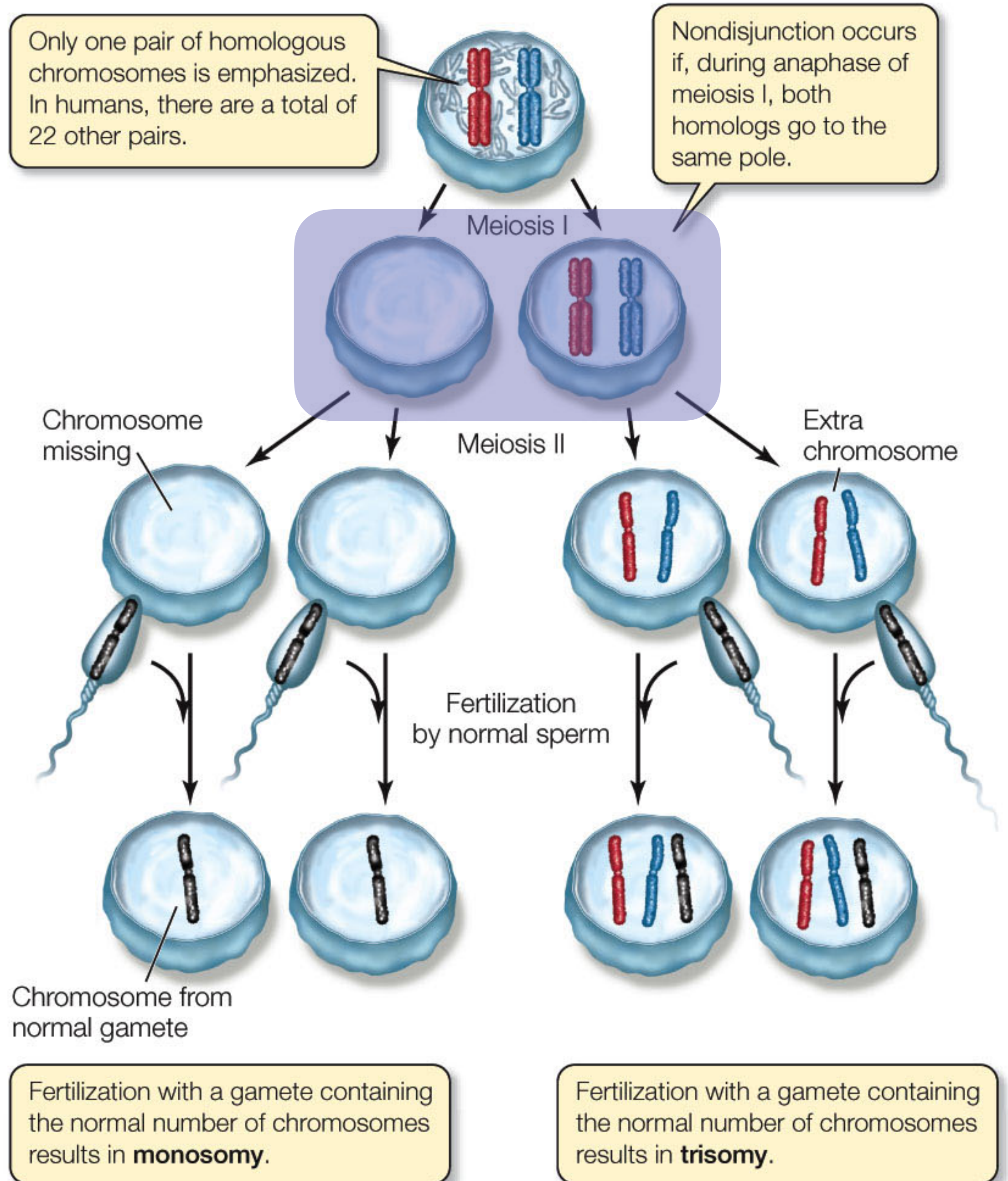

Figure 11.12

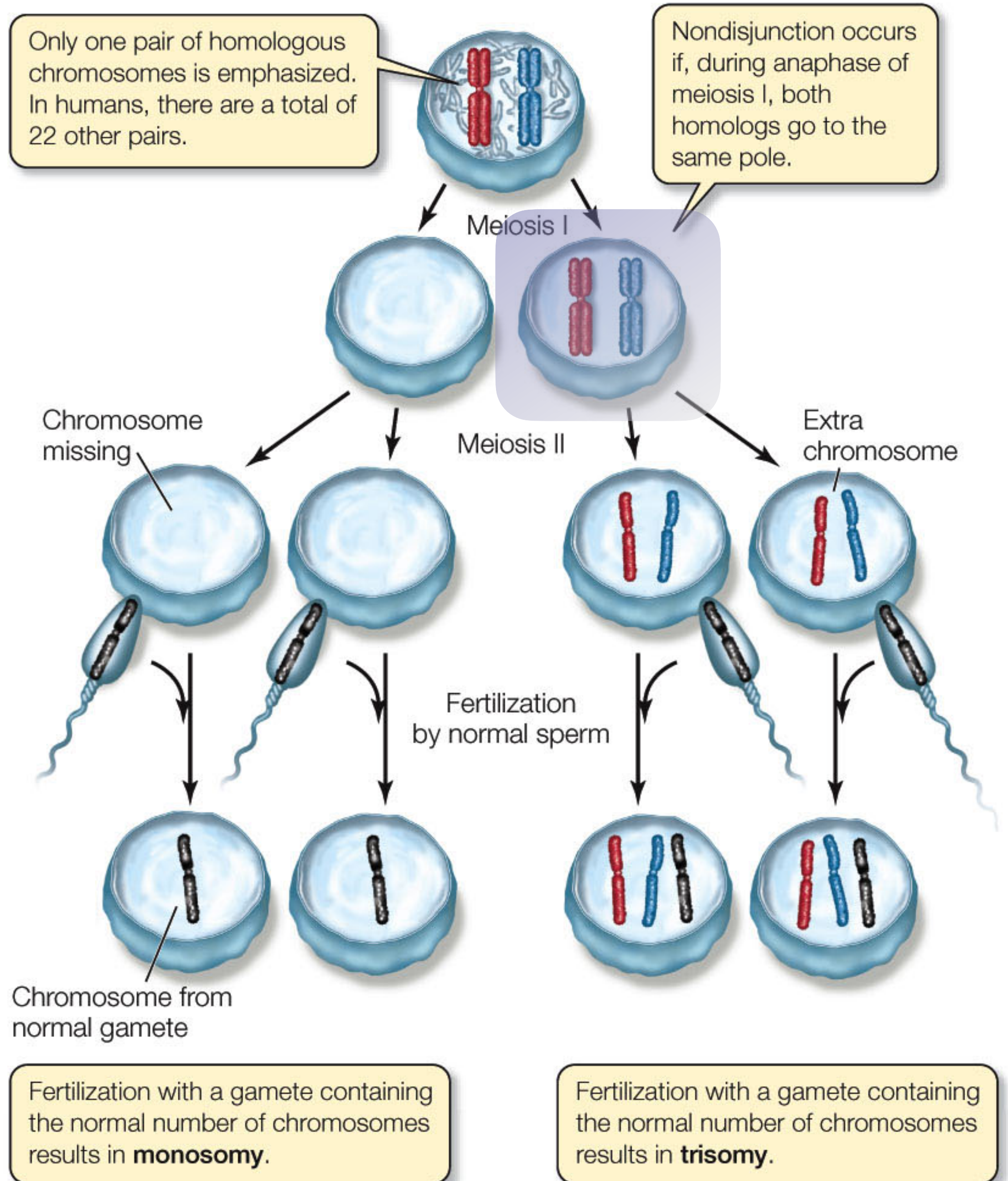
*Biology: How Life Works*, Second Edition

**TABLE 11.1 Comparison of Mitosis and Meiosis.**

| | MITOSIS | MEIOSIS |
|---|---|---|
| **Function** | Asexual reproduction in unicellular eukaryotes<br>Development in multicellular eukaryotes<br>Tissue regeneration and repair in multicellular eukaryotes | Sexual reproduction<br>Production of gametes and spores |
| **Organisms** | All eukaryotes | Most eukaryotes |
| **Number of rounds of DNA synthesis** | 1 | 1 |
| **Number of cell divisions** | 1 | 2 |
| **Number of daughter cells** | 2 | 4 |
| **Chromosome complement of daughter cell compared with parent cell** | Same | Half |
| **Pairing of homologous chromosomes** | No | Meiosis I—Yes<br>Meiosis II—No |
| **Crossing over** | No | Meiosis I—Yes<br>Meiosis II—No |
| **Separation of homologous chromosomes** | No | Meiosis I—Yes<br>Meiosis II—No |
| **Centromere splitting** | Yes | Meiosis I—No<br>Meiosis II—Yes |
| **Separation of sister chromatids** | Yes | Meiosis I—No<br>Meiosis II—Yes |

**Table 11.1**
*Biology: How Life Works*, Second Edition


Only one pair of homologous chromosomes is emphasized. In humans, there are a total of 22 other pairs.
Nondisjunction occurs if, during anaphase of meiosis I, both homologs go to the same pole.
Meiosis I
Chromosome missing
Meiosis II
Extra chromosome
Fertilization by normal sperm
Chromosome from normal gamete
Fertilization with a gamete containing the normal number of chromosomes results in **monosomy**.
Fertilization with a gamete containing the normal number of chromosomes results in **trisomy**.



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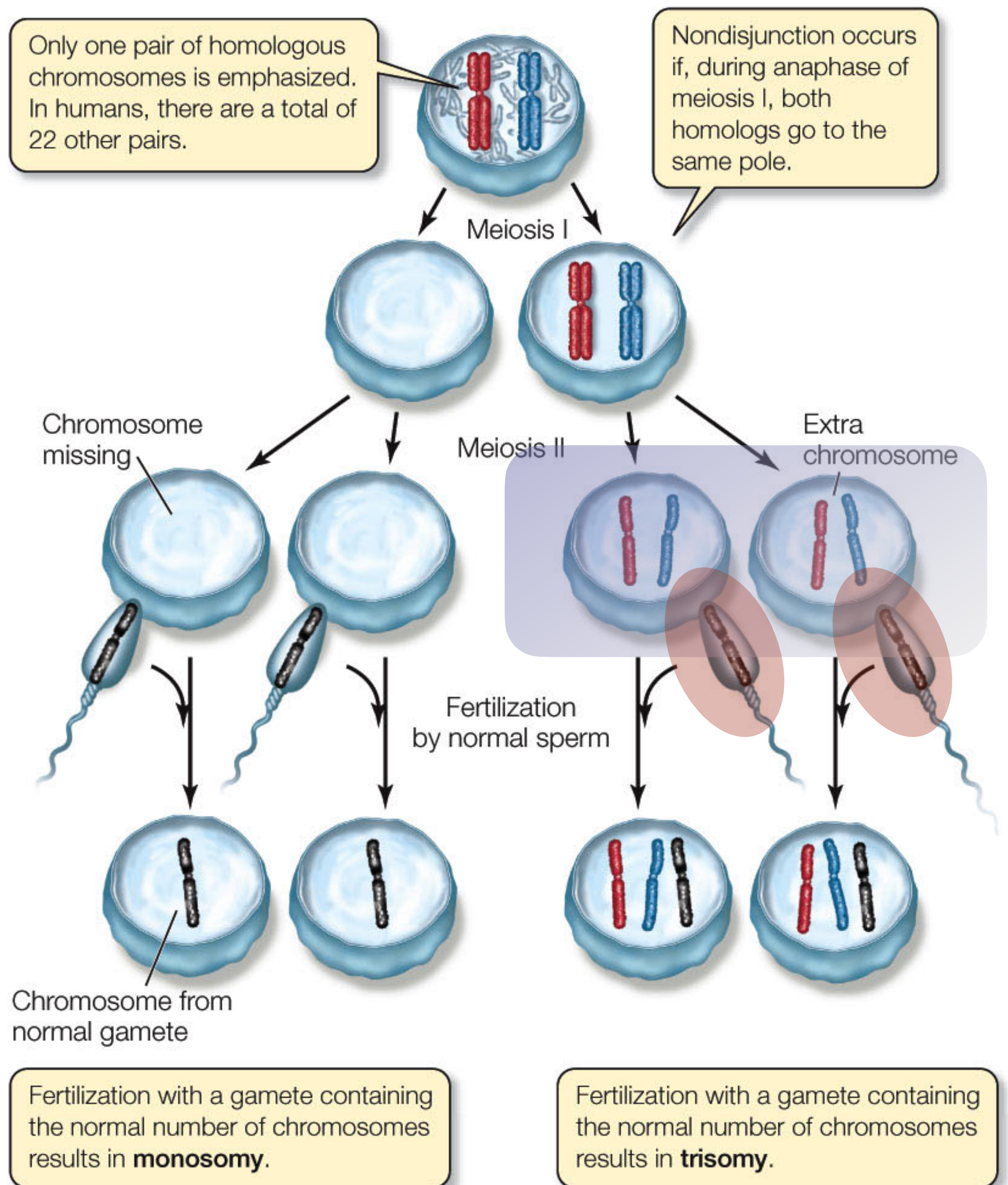
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Nondisjunction occurs if, during anaphase of meiosis I, both homologs go to the same pole.
Meiosis I
Chromosome missing
Meiosis II
Extra chromosome
Fertilization by normal sperm
Chromosome from normal gamete
Fertilization with a gamete containing the normal number of chromosomes results in **monosomy**.
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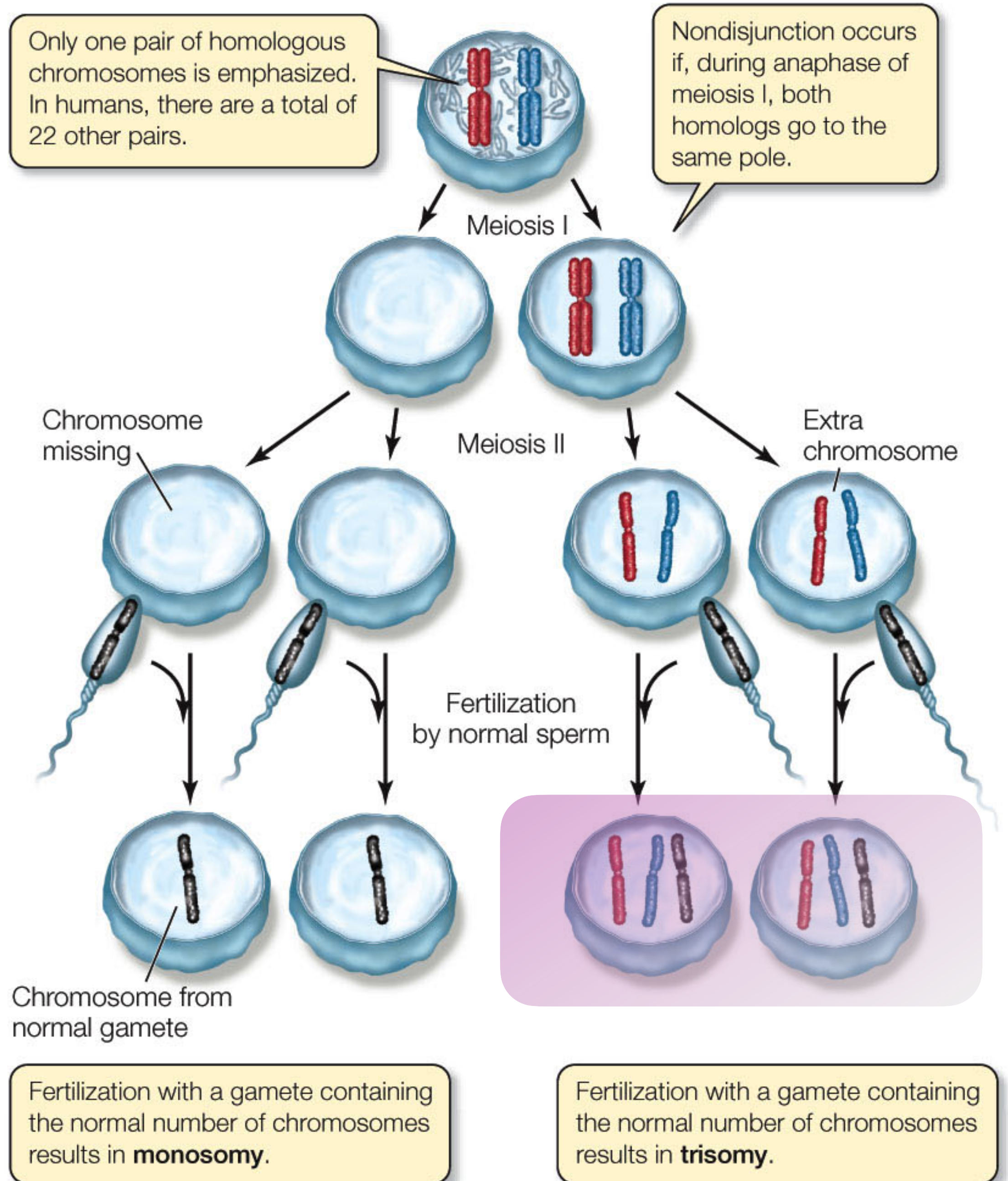
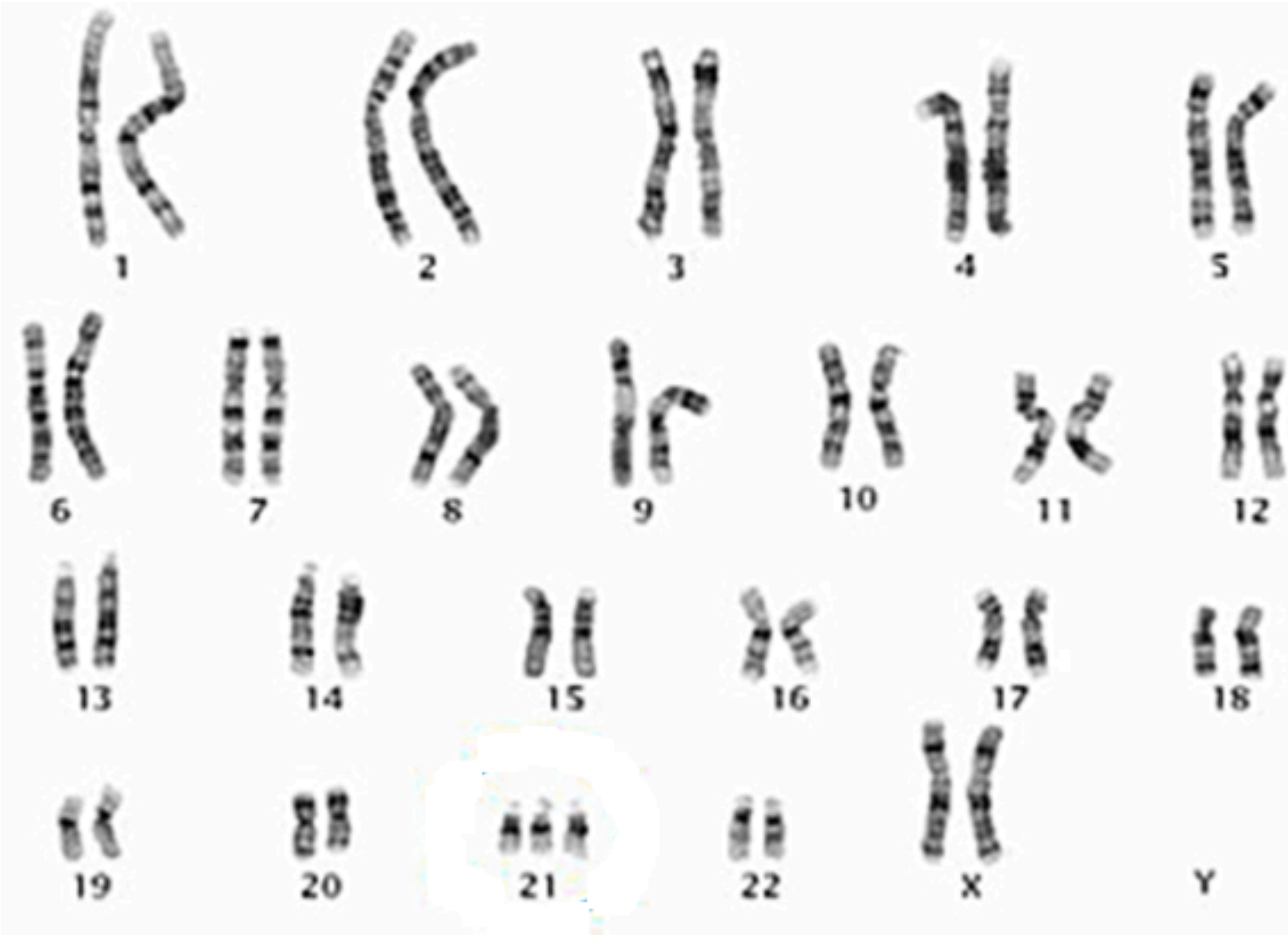


Only one pair of homologous chromosomes is emphasized. In humans, there are a total of 22 other pairs.
Nondisjunction occurs if, during anaphase of meiosis I, both homologs go to the same pole.
Meiosis I
Chromosome missing
Meiosis II
Extra chromosome
Fertilization by normal sperm
Chromosome from normal gamete
Fertilization with a gamete containing the normal number of chromosomes results in **monosomy**.
Fertilization with a gamete containing the normal number of chromosomes results in **trisomy**.


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

# Gregor Mendel

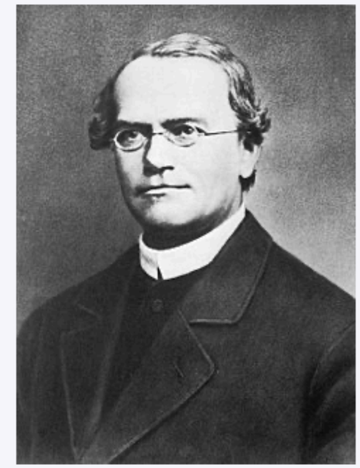
From Wikipedia, the free encyclopedia

**Gregor Johann Mendel** (Czech: *Řehoř Jan Mendel*;[1] 20 July 1822[2] – 6 January 1884) (English: /ˈmɛndəl/) was a scientist, Augustinian friar and abbot of St. Thomas' Abbey in Brno, Margraviate of Moravia. Mendel was born in a German-speaking family[3] in the Silesian part of the Austrian Empire (today's Czech Republic) and gained posthumous recognition as the founder of the modern science of genetics. Though farmers had known for millennia that crossbreeding of animals and plants could favor certain desirable traits, Mendel's pea plant experiments conducted between 1856 and 1863 established many of the rules of heredity, now referred to as the laws of Mendelian inheritance.[4]

Mendel worked with seven characteristics of pea plants: plant height, pod shape and color, seed shape and color, and flower position and color. Taking seed color as an example, Mendel showed that when a true-breeding yellow pea and a true-breeding green pea were cross-bred their offspring always produced yellow seeds. However, in the next generation, the green peas reappeared at a ratio of 1 green to 3 yellow. To explain this phenomenon, Mendel coined the terms "recessive" and "dominant" in reference to certain traits. (In the preceding example, the green trait, which seems to have vanished in the first filial generation, is recessive and the yellow is dominant.) He published his work in 1866, demonstrating the actions of invisible "factors"—now called genes—in predictably determining the traits of an organism.

The profound significance of Mendel's work was not recognized until the turn of the 20th century (more than three decades later) with the rediscovery of his laws.[5] Erich von Tschermak, Hugo de Vries, Carl Correns and William Jasper Spillman independently verified several of Mendel's experimental findings, ushering in the modern age of genetics.[4]

**Gregor Mendel**



| | |
|---|---|
| **Born** | Johann Mendel<br>20 July 1822<br>Heinzendorf bei Odrau, Silesia, Austrian Empire (now Hynčice, Czech Republic) |
| **Died** | 6 January 1884 (aged 61)<br>Brünn, Moravia, Austria-Hungary<br>(now Brno, Czech Republic) |
| **Nationality** | Austrian |
| **Alma mater** | University of Olomouc<br>University of Vienna |
| **Known for** | Creating the science of genetics |
| **Scientific career** | |
| **Fields** | Genetics |
| **Institutions** | St Thomas's Abbey |

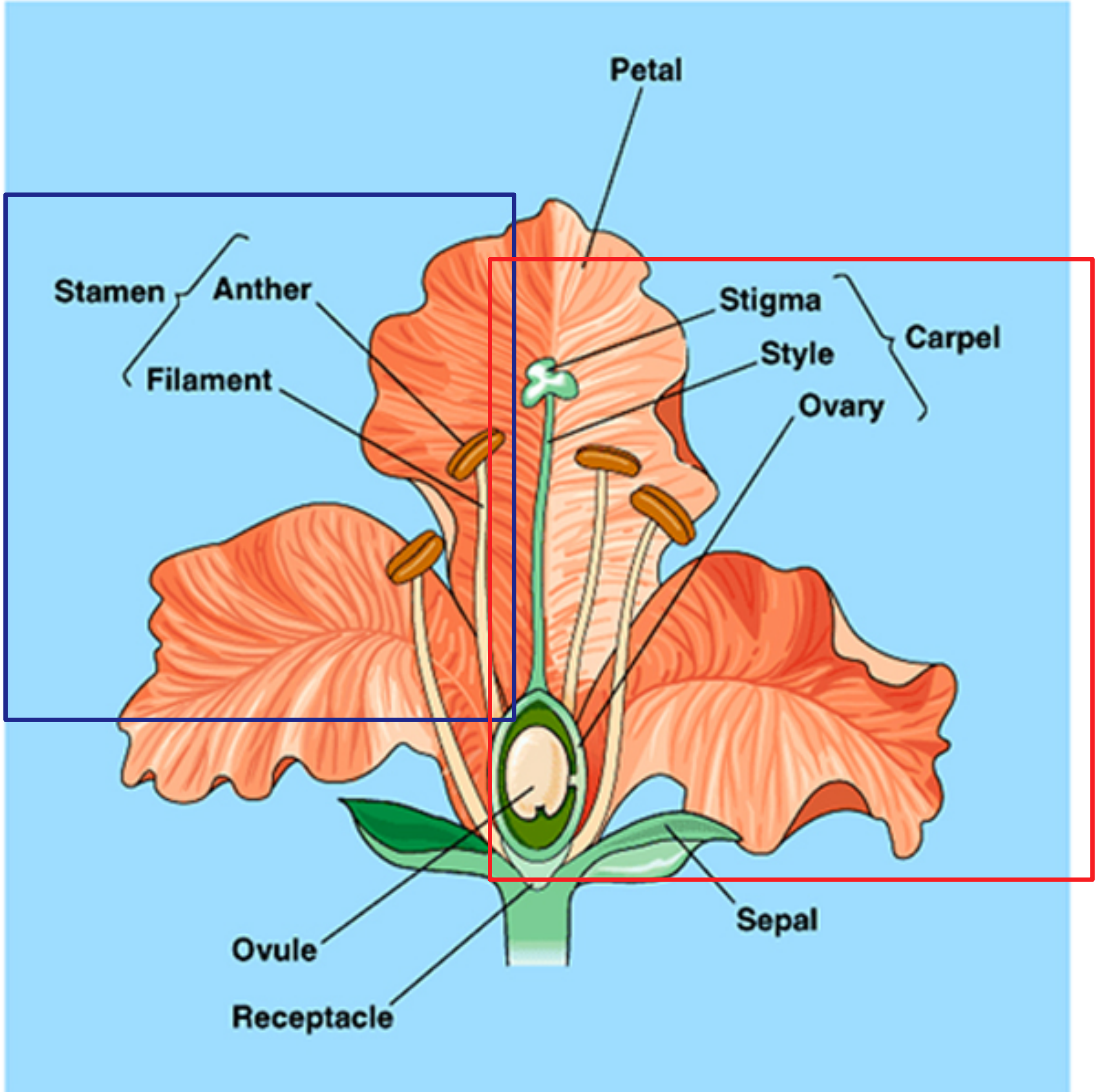
**Contents** [hide]

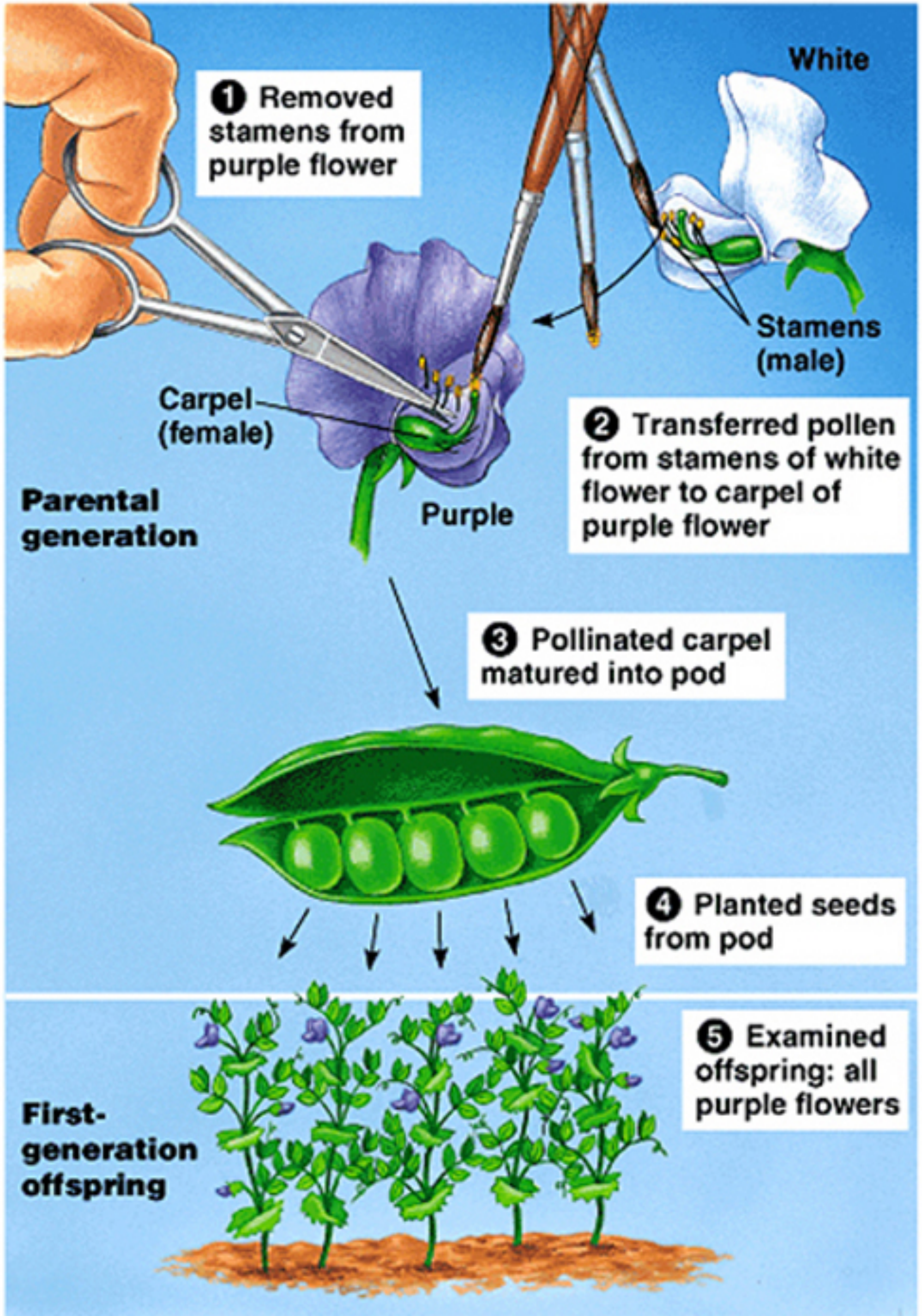




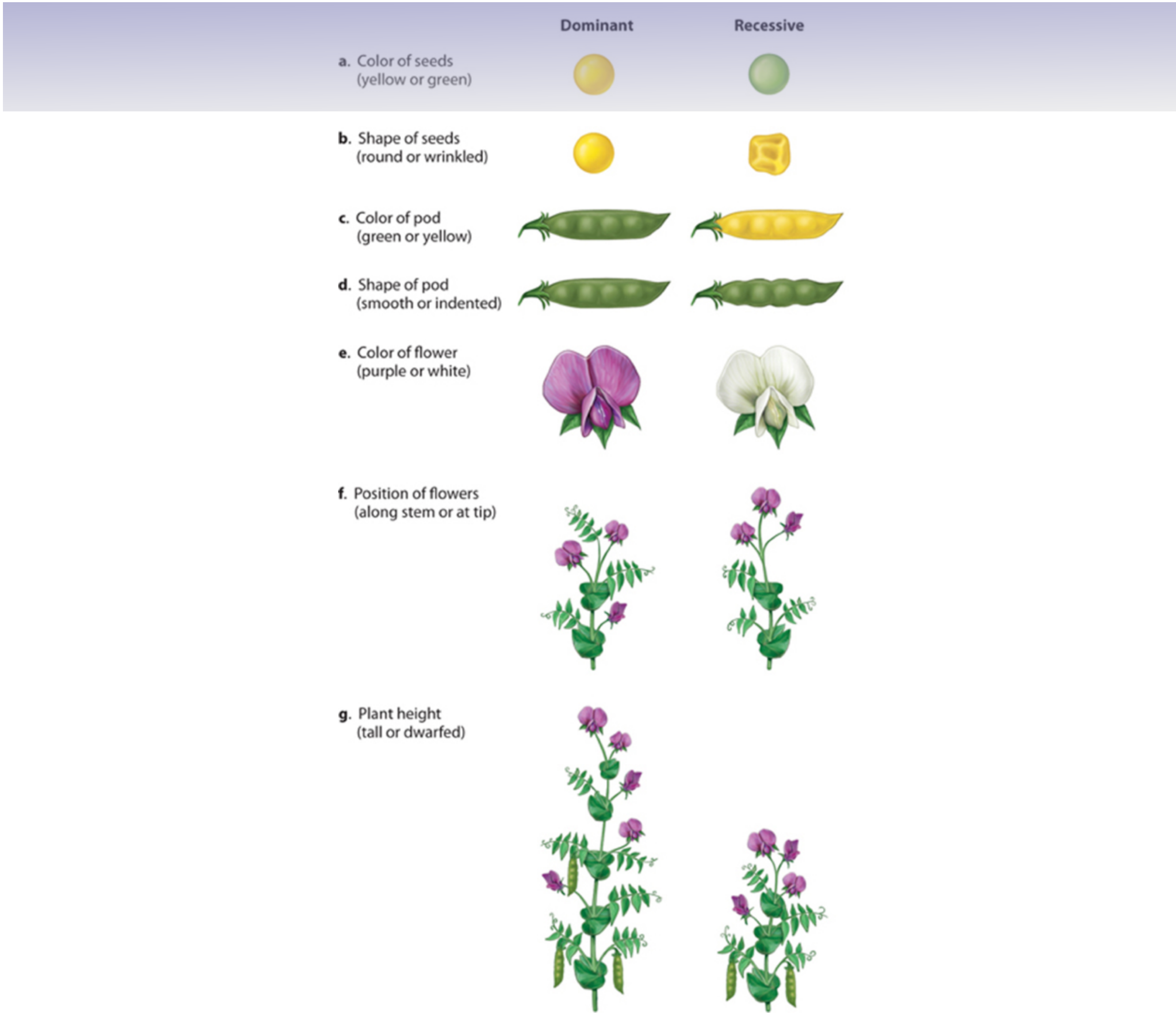
## Life and career

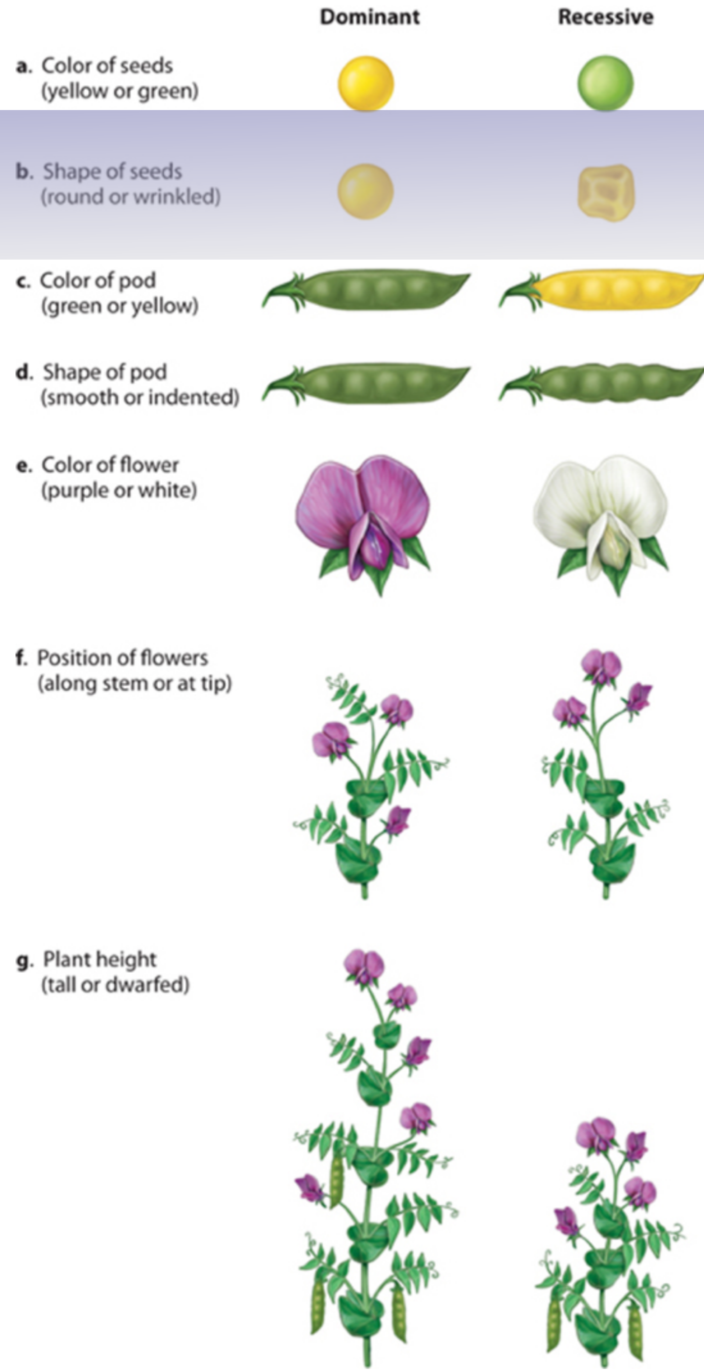
Mendel was born into a German-speaking family in Hynčice (*Heinzendorf bei Odrau* in German), at the Moravian-Silesian border, Austrian Empire (now a part of the Czech Republic).[3] He was the son of Anton and Rosine (Schwirtlich) Mendel and had one older sister, Veronika,


Petal
Stamen
Anther
Filament
Stigma
Style
Carpel
Ovary
Ovule
Receptacle
Sepal

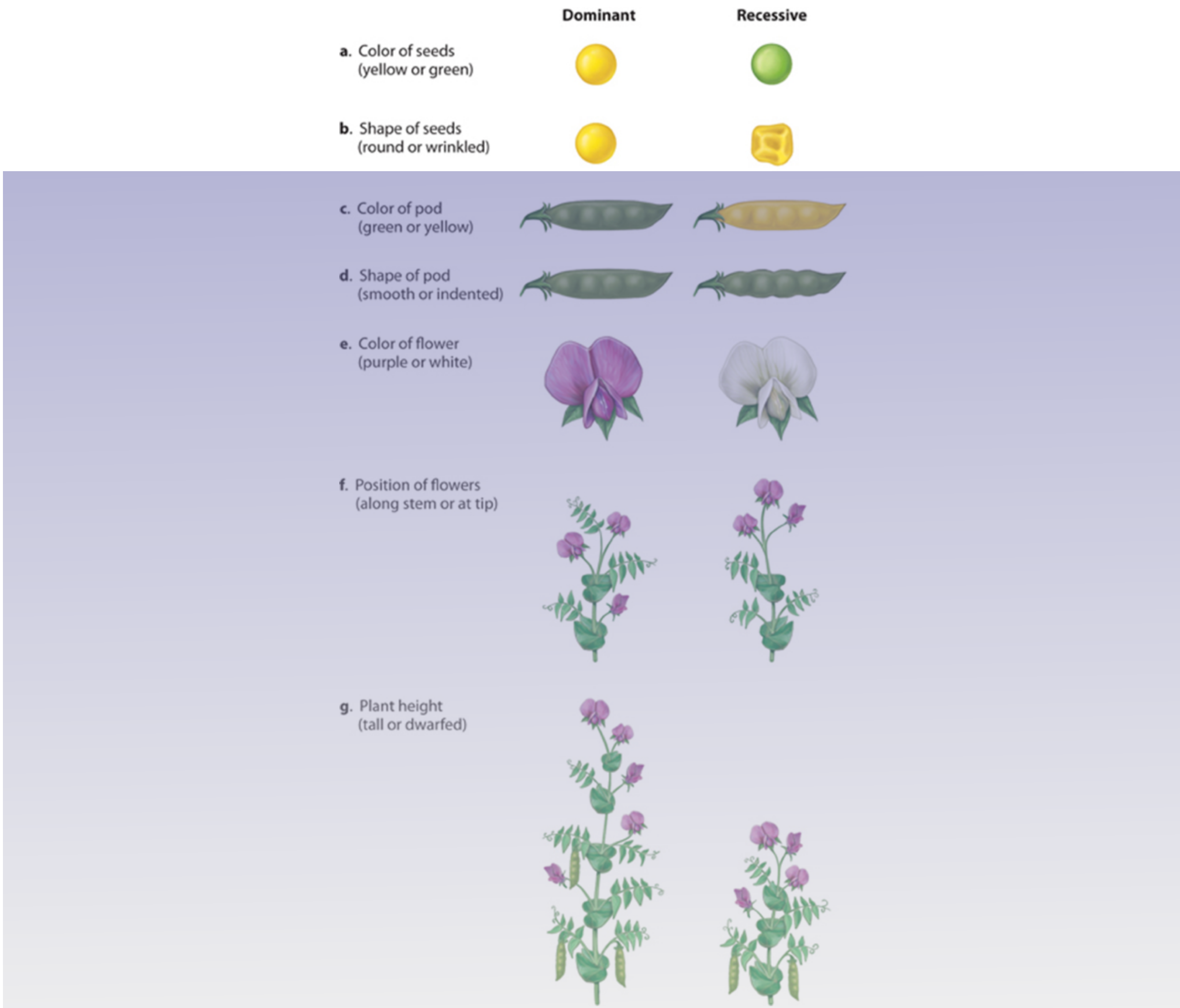


White
1 Removed stamens from purple flower
Stamens (male)
Carpel (female)
2 Transferred pollen from stamens of white flower to carpel of purple flower
Parental generation
Purple
3 Pollinated carpel matured into pod
4 Planted seeds from pod
5 Examined offspring: all purple flowers
First-generation offspring


Dominant
Recessive
a. Color of seeds (yellow or green)
b. Shape of seeds (round or wrinkled)
c. Color of pod (green or yellow)
d. Shape of pod (smooth or indented)
e. Color of flower (purple or white)
f. Position of flowers (along stem or at tip)
g. Plant height (tall or dwarfed)

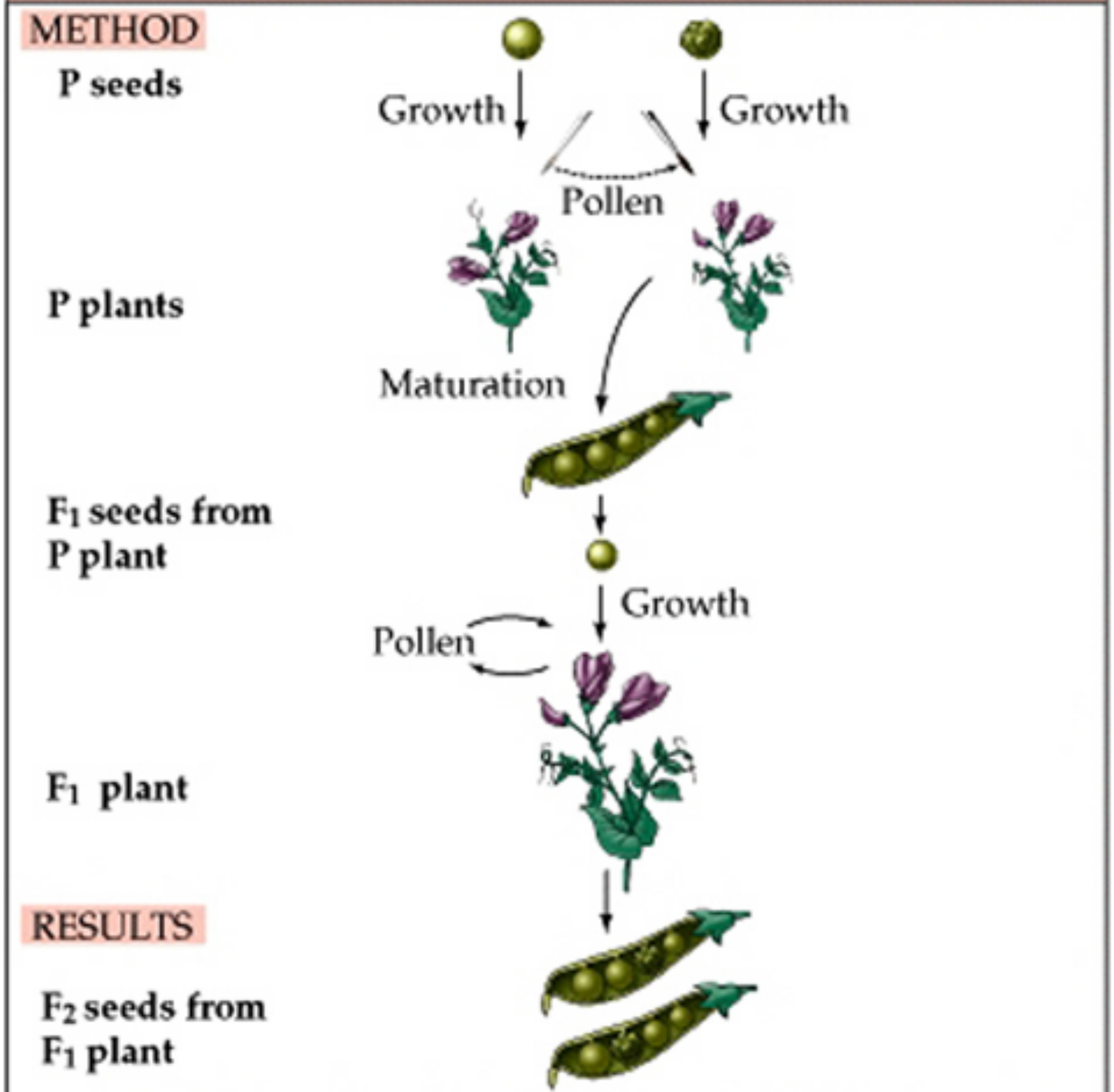


Dominant
Recessive
a. Color of seeds (yellow or green)
b. Shape of seeds (round or wrinkled)
c. Color of pod (green or yellow)
d. Shape of pod (smooth or indented)
e. Color of flower (purple or white)
f. Position of flowers (along stem or at tip)
g. Plant height (tall or dwarfed)


Dominant
Recessive
a. Color of seeds
(yellow or green)
b. Shape of seeds
(round or wrinkled)
c. Color of pod
(green or yellow)
d. Shape of pod
(smooth or indented)
e. Color of flower
(purple or white)
f. Position of flowers
(along stem or at tip)
g. Plant height
(tall or dwarfed)

## EXPERIMENT

**Question:** When two strains with contrasting traits breed, are their characteristics irreversibly blended in succeeding generations?




**Conclusion: There is no irreversible blending of characteristics. A trait can reappear in succeeding generations.**

## Gregor Mendel's hypotheses:

1. Hereditary determinants are of a particulate nature. Each genetic trait is governed by **unit factors** , which "hang around" in pairs (or **gene pairs)** within individual organisms.

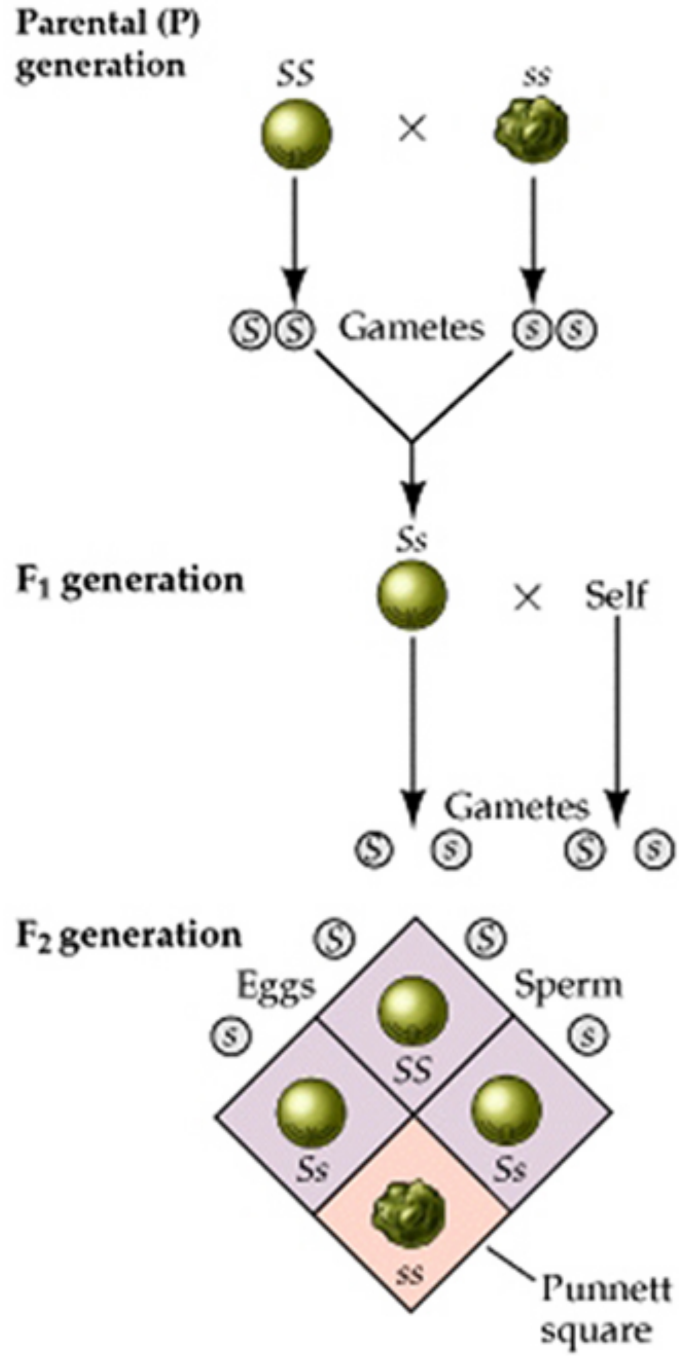
2. When two different unit factors governing the same phenotypical trait occur in the same organism, one of the factors is **dominant** over the other one, which is called the **recessive** trait.

3. During the formation of gametes the "paired" unit factors separate or **segregate randomly** so that each gamete receives either **one or the other** of the two traits, but **only one**.

4. The union of one gamete from each parent to form a resultant zygote **is random** with respect to that particular characteristic.

5. During production of gametes, only one of the "pair members" for a given character passes to the gamete.

6. When fertilization occurs, the zygote gets **one from each parent**, thus restoring the pair.


Parental (P) generation
SS
ss
×
S S Gametes s s
Ss
F1 generation
× Self
Gametes
S s S s
F2 generation
S S
Eggs
Sperm
s s
SS
Ss
Ss
ss
Punnett square

## 10.1 Mendel's Results from Monohybrid Crosses

| DOMINANT × RECESSIVE | DOMINANT | RECESSIVE | TOTAL | RATIO |
|---|---|---|---|---|
| Spherical seeds × Wrinkled seeds | 5,474 | 1,850 | 7,324 | 2.96:1 |
| Yellow seeds × Green seeds | 6,022 | 2,001 | 8,023 | 3.01:1 |
| Purple flowers × White flowers | 705 | 224 | 929 | 3.15:1 |
| Inflated pods × Constricted pods | 882 | 299 | 1,181 | 2.95:1 |
| Green pods × Yellow pods | 428 | 152 | 580 | 2.82:1 |
| Axial flowers × Terminal flowers | 651 | 207 | 858 | 3.14:1 |
| Tall stems × Dwarf stems | 787 | 277 | 1,064 | 2.84:1 |

## 10.1 Mendel's Results from Monohybrid Crosses

| DOMINANT × RECESSIVE | DOMINANT | RECESSIVE | TOTAL | RATIO |
|---|---|---|---|---|
| Spherical seeds × Wrinkled seeds | 5,474 | 1,850 | 7,324 | 2.96:1 |
| Yellow seeds × Green seeds | 6,022 | 2,001 | 8,023 | 3.01:1 |
| Purple flowers × White flowers | 705 | 224 | 929 | 3.15:1 |
| Inflated pods × Constricted pods | 882 | 299 | 1,181 | 2.95:1 |
| Green pods × Yellow pods | 428 | 152 | 580 | 2.82:1 |
| Axial flowers × Terminal flowers | 651 | 207 | 858 | 3.14:1 |
| Tall stems × Dwarf stems | 787 | 277 | 1,064 | 2.84:1 |

## 10.1 **Mendel's Results from Monohybrid Crosses**

| DOMINANT × RECESSIVE | DOMINANT | RECESSIVE | TOTAL | RATIO |
|---|---|---|---|---|
| Spherical seeds × Wrinkled seeds | 5,474 | 1,850 | 7,324 | 2.96:1 |
| Yellow seeds × Green seeds | 6,022 | 2,001 | 8,023 | 3.01:1 |
| Purple flowers × White flowers | 705 | 224 | 929 | 3.15:1 |
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## 10.1 *Mendel's Results from Monohybrid Crosses*

| DOMINANT × RECESSIVE | DOMINANT | RECESSIVE | TOTAL | RATIO |
|---|---|---|---|---|
| Spherical seeds × Wrinkled seeds | 5,474 | 1,850 | 7,324 | 2.96:1 |
| Yellow seeds × Green seeds | 6,022 | 2,001 | 8,023 | 3.01:1 |
| Purple flowers × White flowers | 705 | 224 | 929 | 3.15:1 |
| Inflated pods × Constricted pods | 882 | 299 | 1,181 | 2.95:1 |
| Green pods × Yellow pods | 428 | 152 | 580 | 2.82:1 |
| Axial flowers × Terminal flowers | 651 | 207 | 858 | 3.14:1 |
| Tall stems × Dwarf stems | 787 | 277 | 1,064 | 2.84:1 |

## Mendel's 1st law- the law of segregation

**Mendel's First Law:** Two members of a gene pair segregate from each other into the gametes, whereby one half of the gametes carries one of the traits, the other half carries the other.

## Mendel's 2nd law- the law of random assortment

**Mendel's Second Law:** During gamete formation the segregation of one gene pair is independent of all other gene pairs