Gerald Karp

Cell and Molecular Biology
Fourth Edition

Chapter 14:
Cellular Reproduction

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Interphase

$G_1$: Cell grows and carries out normal metabolism; organelles duplicate

$S$: DNA replication and chromosome duplication

$G_2$: Cell grows and prepares for mitosis

Cytokinesis

Telophase

Anaphase

Metaphase

Prometaphase

Prophase

Mitosis

(M phase)
Mitotic Chromosomes

G₂ Chromosomes

Figure 14-3c Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-6a Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-6b Cell and Molecular Biology, 4/e © 2005 John Wiley & Sons
### Prophase
1. Chromosomal material condenses to form compact mitotic chromosomes. Chromosomes are seen to be composed of two chromatids attached together at the centromere.
2. Cytoskeleton is disassembled and mitotic spindle is assembled.  

### Prometaphase
1. Chromosomal microtubules attach to kinetochores of chromosomes. 
2. Chromosomes are moved to spindle equator.

### Metaphase
1. Chromosomes are aligned along metaphase plate, attached by chromosomal microtubules to both poles.

### Anaphase
1. Centromeres split, and chromatids separate. 
2. Chromosomes move to opposite spindle poles. 
3. Spindle poles move farther apart.

### Telophase
1. Chromosomes cluster at opposite spindle poles. 
2. Chromosomes become dispersed. 
3. Nuclear envelope assembles around chromosome clusters. 
4. Golgi complex and ER reforms. 
5. Daughter cells formed by cytokinesis.

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*Figure 14-11  Cell and Molecular Biology, 4/e © 2005 John Wiley & Sons*
<table>
<thead>
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Figure 14-11 part 1 Cell and Molecular Biology, 4/e © 2005 John Wiley & Sons
**Prometaphase**

1. Chromosomal microtubules attach to kinetochores of chromosomes.
2. Chromosomes are moved to spindle equator.

![Prometaphase diagram]

*Figure 14-11 part 2 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)*
Metaphase

1. Chromosomes are aligned along metaphase plate, attached by chromosomal microtubules to both poles.
**Anaphase**

1. Centromeres split, and chromatids separate.
2. Chromosomes move to opposite spindle poles.
3. Spindle poles move farther apart.

---

Figure 14-11 part 4 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
## Telophase

1. Chromosomes cluster at opposite spindle poles.
2. Chromosomes become dispersed.
3. Nuclear envelope assembles around chromosome clusters.
4. Golgi complex and ER reforms.
5. Daughter cells formed by cytokinesis.

---

*Figure 14-11 part 5  Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)*
Outer kinetochore
microtubule binding
microtubule motor activity
signal transduction

Microtubules

Inner kinetochore
centromere replication
chromatin interface
kinetochore formation

0.2 μm

Figure 14-16a  Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
1. **Interphase**

2. **Early prophase**

3. **Mid-prophase**

4. **Prophase/prometaphase**

**Notes:**
- Dynein
- Site of maximum tension

*Figure 14-20  Cell and Molecular Biology, 4/e © 2005 John Wiley & Sons*
1 Interphase

2 Early prophase

Dynein

Figure 14-20 part 1 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-20 part 2  Cell and Molecular Biology, 4/e © 2005 John Wiley & Sons
4 Prophase/prometaphase

3 Mid-prophase

Site of maximum tension

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Figure 14-26 part 2 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-27 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Anaphase begins

Anaphase continues

Figure 14-28b Cell and Molecular Biology, 4/e © 2005 John Wiley & Sons
Figure 14-31 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Kinetochore

Spindle pole

Microtubule

Cell arrests at metaphase

Monoattached chromosome

Figure 14-31a Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Cell proceeds into anaphase

Tension applied with needle

Figure 14-31b  Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-35a Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-35a part 1  Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Contractile ring

Cleavage furrow

Daughter cells

Figure 14-35a part 2  Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-37c Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-39 part 4 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Gametic or terminal
Gametes (n)
Zygote (2n)

Sporic or intermediate
Animal (2n)

Zygotic or initial
Sporophyte (2n)

Diploid generation (2n)

Meiosis

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Figure 14-44 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
DNA of sister chromatids of one homologous chromosome

Crossover

Recombination nodule

Lateral element (contains cohesin)
Metaphase I
Anaphase I
Figure 14-47 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Figure 14-47 part 1 Cell and Molecular Biology, 4/e (© 2005 John Wiley & Sons)
Phase of cell cycle

- G1
- S
- G2
- Mitosis
- G1