Overview: The Key Roles of Cell Division

- The ability of organisms to reproduce best distinguishes living things from nonliving matter
- In unicellular organisms, division of one cell reproduces the entire organism
- Most cell division results in daughter cells with identical genetic information, DNA
- A special type of division produces nonidentical daughter cells (gametes, or sperm and egg cells)
- Prokaryotes (bacteria and archaea) reproduce by a type of cell division called binary fission

In binary fission, the chromosome replicates (beginning at the origin of replication), and the two daughter chromosomes actively move apart.
The Evolution of Mitosis

- Since prokaryotes evolved before eukaryotes, mitosis probably evolved from binary fission.
- Certain protists exhibit types of cell division that seem intermediate between binary fission and mitosis.

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Fig. 12-12

- (a) Bacteria
  - Bacterial chromosome
  - Chromosomes
  - Microtubules
  - Intact nuclear envelope
- (b) Dinoflagellates
  - Kinetochore
  - Microtubule
  - Intact nuclear envelope
- (c) Diatoms and yeasts
  - Kinetochore
  - Microtubule
  - Fragments of nuclear envelope
- (d) Most eukaryotes

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Fig. 12-5

- S (DNA synthesis)
- G1
- G2
-一共

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Fig. 12-UN1

Telophase and Cytokinesis

Anaphase

Metaphase

Prometaphase

Prophase

MITOTIC (M) PHASE

Cytokinesis

Mitosis

SG1

G2

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Fig. 12-4

Chromosomes

Chromosome duplication (including DNA synthesis)

Chromosome arm

Centromere

Sister chromatids

DNA molecules

Separation of sister chromatids

Centromere

Sister chromatids

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Fig. 12-7

Microtubules

Chromosomes

Sister chromatids

Aster

Metaphase plate

Centrosome

Kinetochore

Kinetochore microtubules

Overlapping nonkinetochore microtubules

• The mitotic spindle is an apparatus of microtubules that controls chromosome movement. The spindle includes the centrosomes, the spindle microtubules, and the aster.
During prometaphase, some spindle microtubules attach to the kinetochores of chromosomes and begin to move the chromosomes.

At metaphase, the chromosomes are all lined up at the metaphase plate, the midway point between the spindle's two poles.

The microtubules shorten by depolymerizing at their kinetochore ends.
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- In animal cells, cytokinesis occurs by a process known as cleavage, forming a cleavage furrow.

- In plant cells, a cell plate forms during cytokinesis.

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Concept 12.3: The eukaryotic cell cycle is regulated by a molecular control system

- The frequency of cell division varies with the type of cell.
- These cell cycle differences result from regulation at the molecular level.
- The sequential events of the cell cycle are directed by a distinct cell cycle control system, which is similar to a clock.
- The cell cycle control system is regulated by both internal and external controls.

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Fig. 12-14

The clock has specific checkpoints where the cell cycle stops until a go-ahead signal is received.
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- For many cells, the G₁ checkpoint seems to be the most important one
- If a cell receives a go-ahead signal at the G₁ checkpoint, it will usually complete the S, G₂, and M phases and divide
- If the cell does not receive the go-ahead signal, it will exit the cycle, switching into a nondividing state called the G₀ phase

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![Diagram showing G₁ checkpoint]

(a) Cell receives a go-ahead signal
(b) Cell does not receive a go-ahead signal

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**The Cell Cycle Clock: Cyclins and Cyclin-Dependent Kinases**

- Two types of regulatory proteins are involved in cell cycle control: cyclins and cyclin-dependent kinases (Cdns)
- The activity of cyclins and Cdns fluctuates during the cell cycle
- MPF (maturation-promoting factor) is a cyclin-Cdk complex that triggers a cell’s passage past the G₂ checkpoint into the M phase
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(b) Molecular mechanisms that help regulate the cell cycle

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**Stop and Go Signs: Internal and External Signals at the Checkpoints**

- An example of an internal signal is that kinetochores not attached to spindle microtubules send a molecular signal that delays anaphase.
- Some external signals are **growth factors**, proteins released by certain cells that stimulate other cells to divide.
- For example, platelet-derived growth factor (PDGF) stimulates the division of human fibroblast cells in culture.

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- Another example of external signals is **density-dependent inhibition**, in which crowded cells stop dividing.
- Most animal cells also exhibit **anchorage dependence**, in which they must be attached to a substratum in order to divide.