Chapter 12

The Cell Cycle

PowerPoint Lectures for
***Biology*, Seventh Edition**
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Lectures by Chris Romero

- Overview: The Key Roles of Cell Division
- The continuity of life
  - Is based upon the reproduction of cells, or cell division

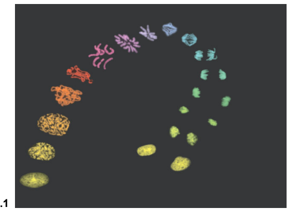
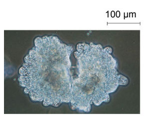


Figure 12.1

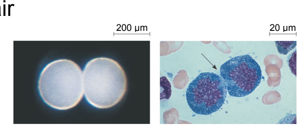
- Unicellular organisms
  - Reproduce by cell division



(a) Reproduction. An amoeba, a single-celled eukaryote, is dividing into two cells. Each new cell will be an individual organism (LM).

Figure 12.2 A

- Multicellular organisms depend on cell division for
  - Development from a fertilized cell
  - Growth
  - Repair



(b) Growth and development. This micrograph shows a sand dollar embryo shortly after the fertilized egg divided, forming two cells (LM).

(c) Tissue renewal. These dividing bone marrow cells (arrow) will give rise to new blood cells (LM).

Figure 12.2 B, C

- The cell division process
  - Is an integral part of the cell cycle

- Concept 12.1: Cell division results in genetically identical daughter cells
- Cells duplicate their genetic material
  - Before they divide, ensuring that each daughter cell receives an exact copy of the genetic material, DNA

Cellular Organization of the Genetic Material

- A cell's endowment of DNA, its genetic information
  - Is called its genome

- The DNA molecules in a cell
  - Are packaged into chromosomes

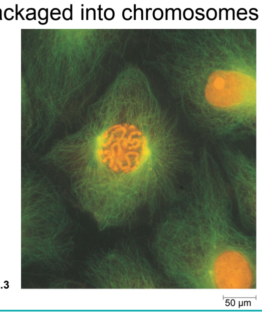


Figure 12.3

- Eukaryotic chromosomes
  - Consist of chromatin, a complex of DNA and protein that condenses during cell division
- In animals
  - Somatic cells have two sets of chromosomes
  - Gametes have one set of chromosomes

Distribution of Chromosomes During Cell Division

- In preparation for cell division
  - DNA is replicated and the chromosomes condense

- Each duplicated chromosome
  - Has two sister chromatids, which separate during cell division

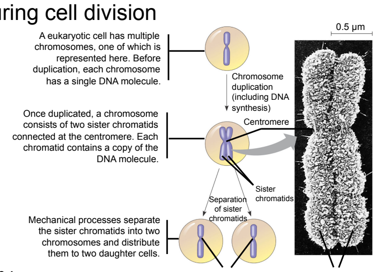


Figure 12.4

- Eukaryotic cell division consists of
  - Mitosis, the division of the nucleus
  - Cytokinesis, the division of the cytoplasm
- In meiosis
  - Sex cells are produced after a reduction in chromosome number

- Concept 12.2: The mitotic phase alternates with interphase in the cell cycle
- A labeled probe can reveal patterns of gene expression in different kinds of cells

Phases of the Cell Cycle

- The cell cycle consists of
  - The mitotic phase
  - Interphase

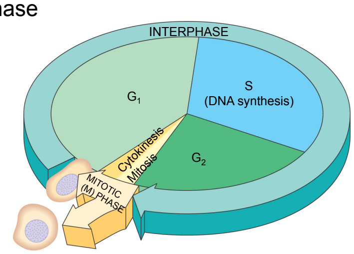


Figure 12.5

- Interphase can be divided into subphases
  - G_1 phase
  - S phase
  - G_2 phase

- The mitotic phase
  - Is made up of mitosis and cytokinesis

- Mitosis consists of five distinct phases
  - Prophase
  - Prometaphase

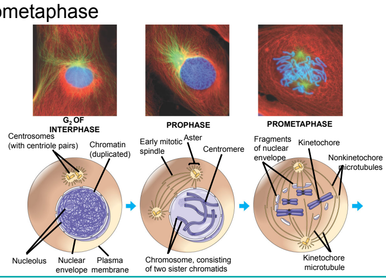


Figure 12.6

- Metaphase
- Anaphase
- Telophase

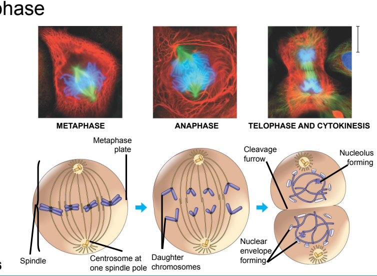


Figure 12.6

The Mitotic Spindle: *A Closer Look*

- The mitotic spindle
  - Is an apparatus of microtubules that controls chromosome movement during mitosis

- The spindle arises from the centrosomes
  - And includes spindle microtubules and asters

- Some spindle microtubules
  - Attach to the kinetochores of chromosomes and move the chromosomes to the metaphase plate

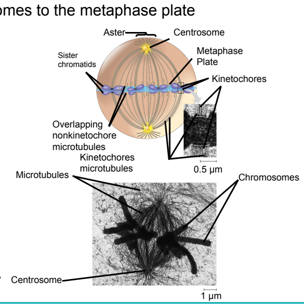


Figure 12.7

- In anaphase, sister chromatids separate
  - And move along the kinetochore microtubules toward opposite ends of the cell

EXPERIMENT

1 The microtubules of a cell in early anaphase were labeled with a fluorescent dye that glows in the microscope (yellow).

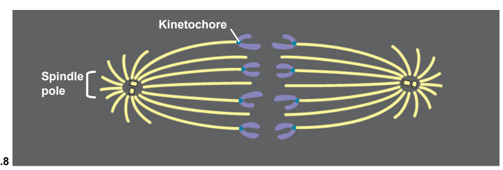


Figure 12.8

- Nonkinetechore microtubules from opposite poles
  - Overlap and push against each other, elongating the cell
- In telophase
  - Genetically identical daughter nuclei form at opposite ends of the cell

Cytokinesis: *A Closer Look*

- In animal cells
  - Cytokinesis occurs by a process known as cleavage, forming a cleavage furrow

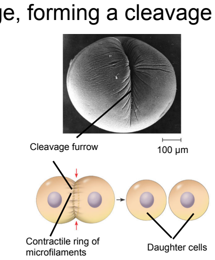


Figure 12.9 A (a) Cleavage of an animal cell (SEM)

- In plant cells, during cytokinesis
  - A cell plate forms

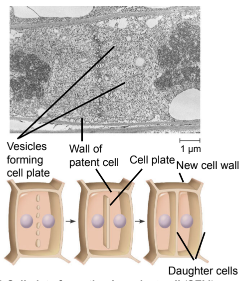


Figure 12.9 B(b) Cell plate formation in a plant cell (SEM)

- Mitosis in a plant cell

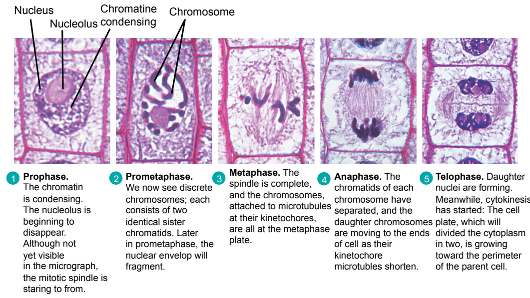


Figure 12.10

Binary Fission

- Prokaryotes (bacteria)
  - Reproduce by a type of cell division called binary fission

- In binary fission
  - The bacterial chromosome replicates
  - The two daughter chromosomes actively move apart

1 Chromosome replication begins. Soon thereafter, one copy of the origin moves rapidly toward the other end of the cell.

2 Replication continues. One copy of the origin is now at each end of the cell.

3 Replication finishes. The plasma membrane grows inward, and new cell wall is deposited.

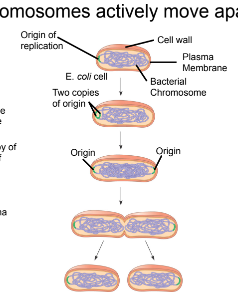


Figure 12.11 4 Two daughter cells result.

The Evolution of Mitosis

- Since prokaryotes preceded eukaryotes by billions of years
  - It is likely that mitosis evolved from bacterial cell division
- Certain protists
  - Exhibit types of cell division that seem intermediate between binary fission and mitosis carried out by most eukaryotic cells

- A hypothetical sequence for the evolution of mitosis

(a) **Prokaryotes.** During binary fission, the origins of the daughter chromosomes move to opposite ends of the cell. The mechanism is not fully understood, but proteins may anchor the daughter chromosomes to specific sites on the plasma membrane.

(b) **Dinoflagellates.** In unicellular protists called dinoflagellates, the nuclear envelope remains intact during cell division, and the chromosomes attach to the nuclear envelope. Microtubules pass through the nucleus inside cytoplasmic tunnels, reinforcing the spatial orientation of the nucleus, which then divides in a fission process reminiscent of bacterial division.

(c) **Diatoms.** In another group of unicellular protists, the diatoms, the nuclear envelope also remains intact during cell division. But in these organisms, the microtubules form a spindle *within* the nucleus. Microtubules separate the chromosomes, and the nucleus splits into two daughter nuclei.

(d) **Most eukaryotes.** In most other eukaryotes, including plants and animals, the spindle forms outside the nucleus, and the nuclear envelope breaks down during mitosis. Microtubules separate the chromosomes, and the nuclear envelope then re-forms.

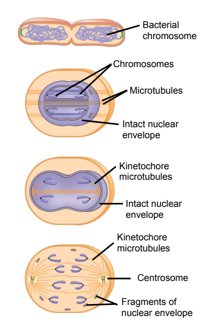


Figure 12.12 A-D

- Concept 12.3: The 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

Evidence for Cytoplasmic Signals

- Molecules present in the cytoplasm
  - Regulate progress through the cell cycle

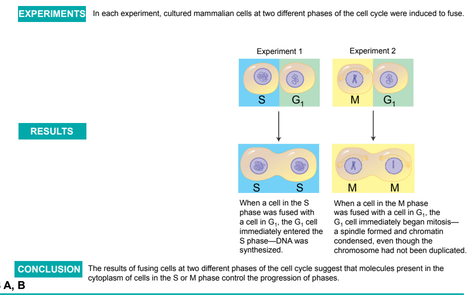


Figure 12.13 A, B

The Cell Cycle Control System

- The sequential events of the cell cycle
  - Are directed by a distinct cell cycle control system, which is similar to a clock

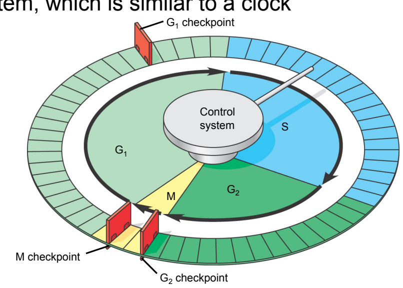


Figure 12.14

- The clock has specific checkpoints
  - Where the cell cycle stops until a go-ahead signal is received

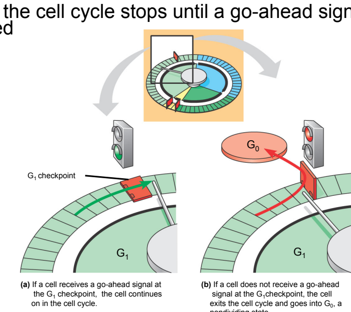


Figure 12.15 A, B

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 (Cdks)

- The activity of cyclins and Cdks
  - Fluctuates during the cell cycle

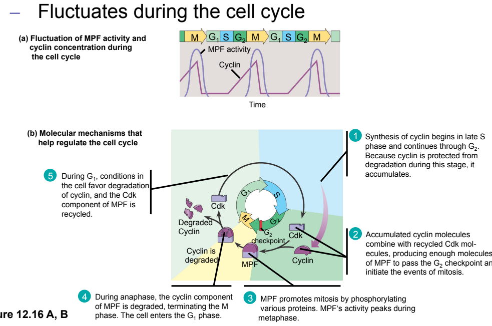


Figure 12.16 A, B

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

- Both internal and external signals
  - Control the cell cycle checkpoints

- Growth factors
  - Stimulate other cells to divide

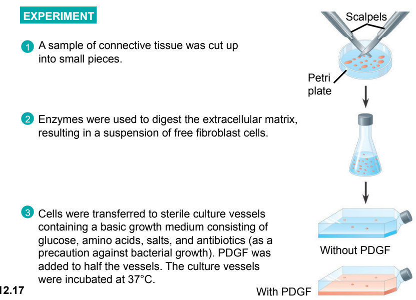


Figure 12.17

- In density-dependent inhibition
  - Crowded cells stop dividing
- Most animal cells exhibit anchorage dependence
  - In which they must be attached to a substratum to divide

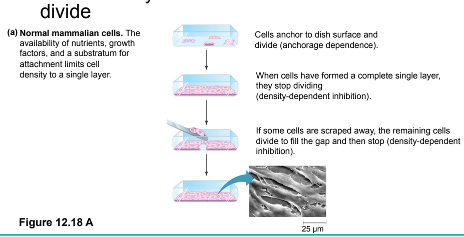


Figure 12.18 A

- Cancer cells
  - Exhibit neither density-dependent inhibition nor anchorage dependence

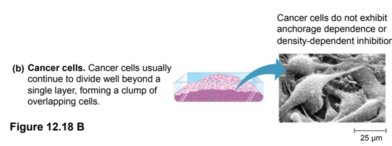


Figure 12.18 B

Loss of Cell Cycle Controls in Cancer Cells

- Cancer cells
  - Do not respond normally to the body's control mechanisms
  - Form tumors

- Malignant tumors invade surrounding tissues and can metastasize
  - Exporting cancer cells to other parts of the body where they may form secondary tumors

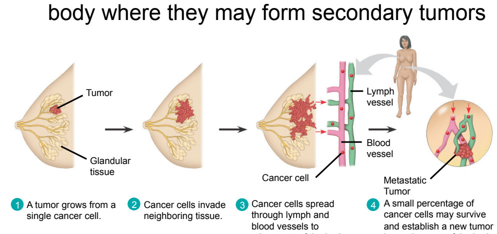


Figure 12.19