# Chapter 10: Cell Growth and Division

| Class | Biology |
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# 10.1 — Cell Growth, Division & Reproduction

## Limits to Cell Size

> A larger cell has more demand on the DNA.

- Less efficient in material transport

### Information Overload

DNA doesn't increase size when the cell does

- DNA cannot serve all needs of the cell

### Exchanging Materials

Surface area increases slower than volume.

- More volume, but less relative surface area
  - Cell membrane cannot serve the cell

> Cells must **DIVIDE** rather than *GROW*.

## Cell Division

Growing cells will form two *daughter cells* before it grows too large.

- **Cell Division:** process by which a cell divides to form two new cells

DNA is replicated before cell division, allowing each cell to have enough genetic information.

- Size of the cell is halved

## Cell Reproduction

**Reproduction:** formation of new individuals

### Asexual Reproduction

**Asexual Reproduction:** production of *genetically-identical* offspring from a single parent

- Simple, efficient, and effective
- Enables population increase at a fast rate
- Mostly unicellular organisms

### Sexual Reproduction

**Sexual Reproduction:** fusion of two separate parent cells to form a new individual

- Inherit some genetic information from EACH parent

| ASEXUAL REPRODUCTION | SEXUAL REPRODUCTION |
|---|---|
| Reproduces faster with good conditions | More time to reproduce |
| Lack of genetic diversity | Genetically-diverse (able to adapt) |

# 10.2 — The Process of Cell Division

## Chromosomes

> Cells need to copy their DNA before reproducing.

- Cells handle DNA by packaging it in **chromosomes**

Chromosomes float in the cytoplasm for prokaryotes

- Single, circular DNA chromosome
- Contains all of the cell's genetic information

Eukaryotic cells have much more DNA than prokaryotes

- Chromosomes form complexes with histone proteins to form **chromatin**

The DNA tightly coil around the histones to form **nucleosomes**.

- Beadlike complexes

Chromosomes allow for the precise separation of DNA during cell division.

# The Cell Cycle

**Cell Cycle:** series of events cells go through as they grow and divide

- Prokaryotes → binary fission (growth, DNA replication, cell division)
- Eukaryotes → 4 stages: $G_1$, S, $G_2$, and M phases

The $G_1$, S, and $G_2$ form **interphase**

- Period of growth in between cell divisions
- 'G' stands for *gap*

## Interphase

**$G_1$ Phase** → growth, size increase, protein & organelle synthesis

**S Phase** → DNA/chromosome replication

**$G_2$ Phase** → organelles & molecules required for cell division are produced

## M Phase

**M Phase** → produces 2 daughter cells

- Interphase takes the bulk of time (M phase is short)

M phase has two stages: *mitosis* and *cytokinesis*.

# Mitosis

## Prophase

- Genetic material condenses
- Duplicated chromosomes are visible
- Spindle forms outside the nucleus
    - **Spindle:** system of microtubules that separate the duplicated chromosomes
        - Extend from the **centromere**
- Centrioles move towards opposite poles of the cell

Prophase is the longest phase (~1/2 of the time)

Duplicated strands of DNA are attached at a **centromere**.

- Each DNA strand is a **chromatid** or **sister chromatid**

**End of Prophase:**

- Chromosomes coil more tightly
- Nucleolus disappears
- Nuclear envelope breaks down

## Metaphase

- Chromosomes line up in the middle of the cell
- Spindle fibers connect to the centromeres

Metaphase is *typically* the shortest phase.

### Anaphase

- Sister chromatids separate and move apart
- Chromosomes are separated into two groups

### Telophase

- Chromosomes spread out into chromatin
- Nuclear envelope re-forms
- Spindle breaks apart
- Nucleolus becomes visible again

## Cytokinesis

**Cytokinesis:** division of the cytoplasm

- Completes cell division

**Cytokinesis in Animal Cells** → cell membrane pinches inward to separate the cells

**Cytokinesis in Plant Cells** → *cell plate* separate the two cells (cell wall is too rigid)

# 10.3 — Regulating the Cell Cycle

## Controls on Cell Division

- **IN LABS -** most cells grow until coming into contact with others

### Cyclins

**Cyclin:** a protein able to regulate the cell cycle

- **Cyclins:** a family of proteins that regulate the timing of the cell cycle

## Regulatory Proteins

> The cell cycle is controlled by **regulatory proteins** in and outside the cell.

- More than just cyclins that can regulate the cell cycle

**Internal Regulators** → respond to events occurring inside the cell

- Allow the cell cycle to *proceed* after certain events occur

**External Regulator Proteins:** proteins that respond to events outside the cell

- **Growth Factors** → stimulate the cell growth and division
  - Some cells do the opposite to stop cell division

## Apoptosis

**Apoptosis:** programmed cell death

1. Cell & chromatin shrink
2. Cell membrane breaks off
3. Neighboring cells clean up the cell's remains

# Cancer

**Cancer:** a bodily disorder where cells lose the ability to control growth

> Cancer cells don't respond to regulatory protein signaling.

- Form masses of cells called **tumors**

Benign tumors **DO NOT** spread. Malignant tumors **DO** spread.

## What Causes Cancer?

- Defects in genes that regulate cell growth and division
    - Smoking or tobacco
    - Radiation
    - Other defective genes
    - Viral infection

Many cancer cells have a gene defect in a gene called **p53**.

- p53 normally halts the cell cycle until proper DNA replication

### Cancer Treatments

- Surgery (localized tumors)
- Radiation therapy
- Chemotherapy (certain compounds made by scientists)

# 10.4 — Cell Differentiation

All life starts from one cell.

- **Embryo:** development stage from which an adult organism is gradually produced

During the developmental process, an organism’s cells differentiate and specialize themselves.

## What is Differentiation?

**Differentiation:** the process by which cells become specialized

- Cells carry out different jobs needed to survive

Biologists can predict how differentiation originates and occurs.

# Stem Cells & Development

The single, fertilized cell is called the **zygote**.

- First cell of the human body
- Considered to be **totipotent** (able to perform all needed bodily functions)

New cells form a **blastocyst**.

- Some cells form tissues and some cells become an embryo
    - The inner cells become **pluripotent** (performing any of the body's cell types but not the tissues surrounding the embryo)

**Stem Cells:** unspecialized cells from which differentiated cells develop from

- Adult stem cells are **multipotent** (can replace cells in the tissues where they are found)
- Stem cells can be grown from embryonic samples

## Stem Cell Research

- **Regenerative Medicine:** a new field of medicine dedicated to the use of stem cells to repair/replace damaged parts of the body
- **Cellular Reprogramming:** ability to "remake" cells into different kinds of cells using stem cell mechanisms
- **Induced Pluripotent Stem Cells (iPS cells) →** bring about the possibility to tailor treatments to individuals

> The use of stem cells bring up ethical dilemmas.

- Stem cells must be harvested from embryonic samples
    - Can be viewed as unethical

- Others view it as unethical to restrict research to save human lives