Mitosis and meiosis:
Two types of eukaryotic cell division

- According to the Cell Theory, new cells are created by the division of existing cells.

- There are two types of eukaryotic cell division: Mitosis and meiosis.

- Examples in the human body:
  - Mitosis is done to make more of a specific body cell.
  - Meiosis is done by certain cells in ovaries or testes to create gametes (eggs or sperm).
Interphase: Preparations for mitosis or meiosis

- A eukaryotic cell has a “laundry list” of preparations it must do to ready for mitosis or meiosis. The time spent completing the preparations is called Interphase.

- An important preparation is the duplication of chromosomes. The two chromosome copies, called “sister chromatids”, remain together until late in cell division.

- Another preparation is the formation of a protein structure called the spindle, which begins in late Interphase.
Mitosis: Introduction

• In mitosis, a eukaryotic cell divides to produce two identical “daughter” cells

• Human somatic (body) cells divide by mitosis at some point in their lives, though at different rates
  • Some cells, such as skin cells, divide rapidly
  • Some cells, such as nerve cells, divide extremely slowly

• There are two major events in the process of mitosis:
  1. Equal division of the cell’s chromosomes
  2. Division of the cell’s cytoplasm

Many other cell structures are divided in the process of mitosis, but these slides will focus on the above two events.
Mitosis: Overview of the process

Mitosis may be divided into the following stages:

- **Prophase** - Start of mitosis
- **Prometaphase** - Setting up chromosome alignment
- **Metaphase** - Chromosomes line up in middle of cell
- **Anaphase** - Sister chromatids separate
- **Telophase** - Final steps of chromosome division

- **Cytokinesis** - Division of cytoplasm
Prophase

• The chromosomes condense

• Nuclear envelope begins to break down

• The spindle continues to form:
  Two centrosomes migrate to opposite sides of the cell, while long spindle fibers extend out of them
Prometaphase: Preparation for chromosome alignment

- Nuclear envelope disappears
- Chromosomes are fully condensed
- Some spindle fibers attach to sister chromatids.

The location on a chromatid where the attachment occurs is called the centromere.
Metaphase:
Chromosomes align in middle of cell

- Spindle fibers help chromosomes move so that they align in the middle of the cell
Anaphase: Separating sister chromatids

- Sister chromatids (identical chromosome copies) are separated from each other
  - The spindle fibers shorten
  - The chromatids are pulled to opposite sides of the cell.

Once they begin to separate, each chromatid is considered a chromosome.
Telophase: Final events of mitosis

- Chromosomes become less condensed
- Spindle fibers are fully disassembled
- The nuclear envelope reforms
Cytokinesis: Dividing the cytoplasm

- In animal cells, the cell membrane is pinched off to divide the cell into two.
- The two daughter cells are identical to each other.
- Each daughter cell is also identical to the original cell.
Summary of mitosis

• Before mitosis is **Interphase**, where the cell carries out preparations for cell division. Important preparations include chromosome replication and the start of spindle formation.

• The phases of mitosis are:
  
  “Pretty People Meet And Talk”

  - Prophase ➔ Prometaphase ➔ Metaphase ➔ Anaphase ➔ Telophase

• Mitosis results in daughter cells that are identical
Meiosis: Introduction

- In meiosis, a eukaryotic cell produces daughter cells that are very different from it and from each other
  - Regions of DNA in a chromosome have been shuffled by a process called **crossing over**
  - Whole chromosomes have been shuffled by a process called **independent assortment**
  - Each daughter cell has half the number of chromosomes as the original one

- In the human body, specific cells in the ovaries and testes divide by meiosis. The daughter cells they produce are gametes (eggs or sperm).
Meiosis: Overview of the process

- Meiosis consists of two rounds of cell division: Meiosis I and Meiosis II.

- Each round has its own Prophase, Prometaphase (left out for simplicity), Metaphase, Anaphase, Telophase and cytokinesis.

For example, “Prophase I” is the Prophase of Meiosis I, while “Prophase II” is the Prophase of Meiosis II.
Meiosis: Overview of the process

- Animal cells have two sets of chromosomes, one set from each parent.

  An organism with two chromosome sets is diploid, or $2n$.

- Prior to meiosis, each chromosome is duplicated so that it consists of two sister chromatids.

The next few slides focus on some of the major events that occur in the process of meiosis.
Meiosis I: Major events

• Prophase I
  • Nuclear envelope disassembles
  • Spindle forms
  • Chromosomes condense and pair up
  • Crossing over occurs: Paired chromosomes exchange DNA

• Metaphase I
  • Chromosomes remain paired
  • Spindle fibers push chromosome pairs to middle of the cell

• Anaphase I
  • Spindle fibers shorten
  • Paired chromosomes are separated
Meiosis I: Major events

- **Telophase I**
  - Spindle fibers disassemble
  - Chromosomes become less condensed
  - Nuclear envelope might reform

- **Cytokinesis**
  - The cell divides into two
  - Each daughter cell only has one set of chromosomes – they are each haploid, or $n$
Meiosis II: Major events

- Prophase II
  - Nuclear envelope disassembles (if reformed in Meiosis I)
  - Spindle forms
  - Chromosomes condense

- Metaphase II
  - Spindle fibers chromosomes to middle of the cell

- Anaphase II
  - Sister chromatids are separated
Meiosis II: Major events

- Telophase II
  - Spindle fibers disassemble
  - Chromosomes become less condensed
  - Nuclear envelope reforms

- Cytokinesis
  - Cell divides into two
  - Each daughter cell is haploid, or $n$
Meiosis creates genetic variety

- Meiosis ensures that gametes will be genetically different from each other.

- If there is genetic variation in gametes, each offspring will also be at least a little different from each other and from their parents.

These new gene combinations may be better than the combinations of previous generations!
Meiosis: Crossing over

- In crossing over, paired chromosomes exchange DNA with each other
- This exchange can occur at one or multiple locations along the paired chromosomes
- Must be an equal exchange!
Meiosis: Independent assortment

- Chromosomes pairs are pushed to the middle of the cell in Metaphase I

- The alignment chromosomes in each pair is random

- This random alignment affects which chromosome in the pair will get into a daughter cell when they are separated in Anaphase I
Summary of Meiosis

- Before mitosis is Interphase, where the cell carries out preparations for cell division. Important preparations include chromosome replication and the start of spindle formation.

- Consists of two rounds of cell division, Meiosis I and II. Each cell division has its own Prophase, Prometaphase, Metaphase, Anaphase, and Telophase.
Summary of meiosis

• Chromosome variety is created by crossing over and independent assortment

• Meiosis results in daughter cells that differ from each other and from the original cell because of the genetic variety created by crossing over and independent assortment
Mitosis and meiosis: Similarities

- Chromosomes are replicated in advance of mitosis or meiosis, during Interphase

- A spindle forms to help separate chromosomes during mitosis or meiosis

- Both mitosis and meiosis can be divided up into different phases
# Mitosis and meiosis: Differences

<table>
<thead>
<tr>
<th>Mitosis</th>
<th>Meiosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Occurs in somatic (body) cells</td>
<td>1. Occurs in sex cells to form gametes</td>
</tr>
<tr>
<td>2. Consists of one round of cell division</td>
<td>2. Consists of two rounds of cell division</td>
</tr>
<tr>
<td>3. Results in identical daughter cells</td>
<td>3. Results in daughter cells that have half the number of chromosomes.</td>
</tr>
</tbody>
</table>

Chromosomes differ per gamete due to crossing over and independent assortment.
SELF-PREPARATION FOR THE BIOLOGY ASSESSMENT TEST

END OF MODULE 5:
MITOSIS AND MEIOSIS