Section 1: Meiosis

Objectives
- Summarize the events that occur during meiosis.
- Relate crossing-over, independent assortment, and random fertilization to genetic variation.
- Compare spermatogenesis and oogenesis.

Formation of Haploid Cells
- Meiosis is a form of cell division that halves the number of chromosomes when forming specialized reproductive cells, such as gametes or spores.
- Meiosis involves two divisions of the nucleus—meiosis I and meiosis II.
- Before meiosis begins, the DNA in the original cell is replicated. Thus, meiosis starts with homologous chromosomes.
- The eight stages of meiosis are:
  - **Prophase I:** The nuclear envelope breaks down. Homologous chromosomes pair. Crossing-over occurs when portions of a chromatid on one homologous chromosome are broken and exchanged with the corresponding chromatid portions of the other homologous chromosome.
  - **Metaphase I:** The pairs of homologous chromosomes are moved by the spindle to the equator of the cell.
  - **Anaphase I:** The chromosomes of each pair are pulled to opposite poles of the cell by the spindle fibers.
  - **Telophase I:** Individual chromosomes gather at each of the poles. In most organisms, cytokinesis occurs.
  - **Prophase II:** A new spindle forms around the chromosomes.
  - **Metaphase II:** The chromosomes line up along the equator and are attached at their centromeres to spindle fibers.
  - **Anaphase II:** The centromeres divide, and the chromatids (now called chromosomes) move to opposite poles of the cell.
  - **Telophase II:** A nuclear envelope forms around each set of chromosomes, and the cell undergoes cytokinesis.
Stages of Meiosis

Comparing Meiosis and Mitosis (Video clip)
- Both start off with the same number of chromosomes and these chromosomes are paired. Each pair contains 2 homologous chromosomes.

<table>
<thead>
<tr>
<th>Differences</th>
<th>Meiosis</th>
<th>Mitosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromosomes Line Up</td>
<td>Homologous chromosomes pair up to form tetrads; Crossing-over occurs; Resulting chromosomes are different from parent cell.</td>
<td>Chromosomes line up singly; No crossing over occurs.</td>
</tr>
<tr>
<td>Separation of Chromosomes</td>
<td>Chromatids are still attached to each other as the homologous chromosomes separate.</td>
<td>Homologous chromosomes lined up singly and the chromatids separate.</td>
</tr>
<tr>
<td>Result of Division</td>
<td>Each cell produced has only one chromosome out of each pair of homologous chromosomes.</td>
<td>Each cell produced has one copy of both of the homologous chromosomes. Mitosis stops here.</td>
</tr>
<tr>
<td>Second division</td>
<td>The daughter cells divide again. This time the chromatids separate. There are now four daughter cells and each cell has only one copy of every pair of homologous chromosomes.</td>
<td>No second division.</td>
</tr>
</tbody>
</table>
Comparing the Results of Meiosis and Mitosis (Video clip)

<table>
<thead>
<tr>
<th>End Results</th>
<th>Meiosis</th>
<th>Mitosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Cells Produced</td>
<td>4 cells</td>
<td>2 cells</td>
</tr>
<tr>
<td>Chromosome Number</td>
<td>Half as many chromosomes = haploid</td>
<td>Same number of chromosomes = diploid</td>
</tr>
<tr>
<td>Genetic Comparison to Parent Cell</td>
<td>Genetically different</td>
<td>Genetically identical</td>
</tr>
</tbody>
</table>

Meiosis and Genetic Variation

- Meiosis is an important process that allows for the rapid generation of new genetic combinations.
- Three mechanisms make key contributions to this genetic variation:
  1. independent assortment
  2. crossing-over
  3. random fertilization

Independent Assortment

The random distribution of homologous chromosomes during meiosis is called independent assortment.
Crossing-Over and Random Fertilization
- The DNA exchange that occurs during crossing-over adds even more recombination to the independent assortment of chromosomes that occurs later in meiosis.
- Thus, the number of genetic combinations that can occur among gametes is practically unlimited.
- Furthermore, the zygote that forms a new individual is created by the random joining of two gametes.

Crossing-Over of Chromosomes

Importance of Genetic Variation
- Meiosis and the joining of gametes are essential to evolution. No genetic process generates variation more quickly.
- The pace of evolution is sped up by genetic recombination. The combination of genes from two organisms results in a third type, not identical to either parent.

Meiosis in Males
- The process by which sperm are produced in male animals is called spermatogenesis.
- Spermatogenesis occurs in the testes (male reproductive organs), and produces male gametes called sperm.

Formation of Sperm (Video clip)
- During sperm formation, the cytoplasm is divided equally after the 1st meiotic division.
- The cytoplasm is divided equally again after the 2nd meiotic division.
- Thus, 4 sperm result from each cell that begins meiosis.

Meiosis in Females
- The process by which gametes are produced in female animals is called oogenesis.
- Oogenesis occurs in the ovaries (female reproductive organs) and produces female gametes called **ova**.

**Formation of the Egg Cell (Video clip)**
- During egg formation, the cytoplasm is divided unequally after both meiotic divisions.
- One large cell and 3 smaller cells result.
- The 3 smaller cells die.
- Thus only 1 egg or ovum results from each cell that begins meiosis.

**Meiosis in Male and Female Animals**