**Lecture 7**

**Cell cycle. Regulation of the cell cycle. Cell division (mitosis and meiosis). Different types of eukaryotic mitosis (pleuromitosis, orthomitosis). Meiosis. Spore and gamete type of meiosis. Stages of meiotic division.**

1. The Cell Cycle

The cell cycle is a series of stages that a cell goes through as it grows and divides. It is divided into two main phases:

* Interphase: This is the preparation phase where the cell grows, replicates its DNA, and prepares for division. It is divided into three subphases:
  + G1 Phase (Gap 1): Cell growth and production of proteins necessary for DNA replication.
  + S Phase (Synthesis): Replication of DNA, ensuring that each daughter cell receives a complete set of genetic material.
  + G2 Phase (Gap 2): Further growth and preparation for mitosis, including the synthesis of microtubules.
* M Phase (Mitosis): The actual process of cell division, where the replicated DNA is equally distributed into two daughter cells. It is followed by cytokinesis, where the cytoplasm divides, forming two separate cells.

2. Regulation of the Cell Cycle

The cell cycle is tightly regulated by checkpoints that ensure each phase is completed correctly before the cell moves to the next. Key regulatory components include:

* Cyclins and Cyclin-dependent kinases (CDKs): Cyclins are proteins that activate CDKs, which then phosphorylate target proteins to push the cell cycle forward. Different cyclins are active at different stages of the cell cycle.
* Checkpoints:
  + G1 Checkpoint: Ensures the cell is ready for DNA replication.
  + G2 Checkpoint: Verifies if DNA replication was successful before mitosis.
  + Metaphase Checkpoint: Ensures chromosomes are properly aligned before they are separated during mitosis.

If errors are detected, the cell cycle can be paused for repair, or if the damage is irreparable, the cell may undergo programmed cell death (apoptosis).

3. Cell Division

Cell division can occur via two major processes: mitosis and meiosis.

Mitosis

Mitosis is the division of a somatic (non-reproductive) cell into two genetically identical daughter cells. It is vital for growth, tissue repair, and asexual reproduction. The stages of mitosis include:

1. Prophase: Chromosomes condense, the nuclear envelope breaks down, and the mitotic spindle begins to form.
2. Metaphase: Chromosomes align along the metaphase plate in the center of the cell.
3. Anaphase: Sister chromatids are pulled apart toward opposite poles of the cell.
4. Telophase: Chromosomes reach the poles, the nuclear envelope reforms, and the chromosomes de-condense.

Cytokinesis divides the cytoplasm, resulting in two separate daughter cells.

Types of Eukaryotic Mitosis

There are two variations of mitosis in eukaryotic cells:

* Pleuromitosis: A form of mitosis found in some unicellular eukaryotes (e.g., fungi) where the nuclear envelope does not break down. The spindle apparatus forms inside the nucleus, and chromosomes are divided within it.
* Orthomitosis: The more common form of mitosis in most eukaryotes, where the nuclear envelope breaks down, and the mitotic spindle forms in the cytoplasm.

Meiosis

Meiosis is a specialized form of cell division that occurs in the production of gametes (sperm and eggs in animals) or spores in plants and fungi. Meiosis reduces the chromosome number by half, producing four genetically diverse haploid cells from a single diploid cell. This process includes two rounds of division:

* Meiosis I: Homologous chromosomes (pairs of chromosomes, one from each parent) are separated, reducing the chromosome number by half.
* Meiosis II: Similar to mitosis, where sister chromatids are separated, resulting in four haploid cells.

4. Types of Meiosis

There are two main types of meiosis:

1. Gametic Meiosis: This occurs in animals where meiosis results in the formation of gametes (sperm or eggs). In this type, meiosis occurs directly during the formation of reproductive cells.
2. Sporic Meiosis: Found in plants, algae, and fungi, where meiosis produces spores. These spores undergo mitosis to form a multicellular organism, which will eventually produce gametes.

5. Stages of Meiotic Division

Meiosis consists of two distinct stages: Meiosis I and Meiosis II.

* Meiosis I:
  + Prophase I: Homologous chromosomes pair up in a process called synapsis, forming tetrads. Crossing over occurs, where segments of chromosomes are exchanged, promoting genetic diversity.
  + Metaphase I: Homologous pairs align on the metaphase plate.
  + Anaphase I: Homologous chromosomes are pulled apart to opposite poles, but sister chromatids remain together.
  + Telophase I: The cell divides, forming two haploid daughter cells, each with half the original number of chromosomes.
* Meiosis II:
  + Prophase II: Chromosomes condense, and the spindle forms.
  + Metaphase II: Chromosomes align on the metaphase plate.
  + Anaphase II: Sister chromatids are pulled apart to opposite poles.
  + Telophase II: The cell divides again, resulting in four haploid cells.

Each of the four cells produced by meiosis has a unique combination of genetic material, which contributes to the genetic diversity of offspring.

Conclusion

The cell cycle, regulated by checkpoints and proteins like cyclins and CDKs, ensures proper cell growth and division. Mitosis is essential for the growth and repair of somatic cells, while meiosis produces genetically diverse gametes or spores in reproductive cells. Variations in mitosis, such as pleuromitosis and orthomitosis, reveal the diversity of division mechanisms in eukaryotic cells. Understanding these processes is critical to advancing fields like genetics, medicine, and developmental biology.