**Introduction**

As you are reading this chapter, the cells in your body are continuously undergoing cell division. In the human body, there are two types of cell division that control how DNA is replicated. **Mitosis**, one of the two types, involves the replication of a parent cell into two identical daughter cells. Mitotic cell division continuously renews cells for development through the process of Interphase, Prophase, Metaphase, Anaphase, Telophase, and Cytokinesis. **Meiosis** is the second category of cell division that commits a parent cell to the process of replicating into four daughter cells. As the parent cell divides in Meiosis, the daughter cells produced acquire only half the number of chromosomes from the parent. Meiosis occurs in sex cells through the process of Interphase, Prophase (I and II), Metaphase (I and II), Anaphase (I and II), Telophase (I and II), and Cytokinesis. Meiosis may look similar to Mitosis, but there are key differences in each stage that defines Meiosis as a separate cell division from Mitosis.

**Interphase**

**Interphase** is the groundwork of cell division because it is the portion of the cycle that replicates organelles, DNA, and promotes cell growth. Interphase is included in cell division because it is the preconditioning step necessary for Mitosis and Meiosis to take place. The three stages of Interphase are G1, Synthesis, and G2. Interphase is the portion of cell division where the cell spends the majority of its time replicating (Nature, 2017).

**Mitosis**

**Mitosis** is the type of cell division that is universal across all organisms, except viruses, and it replicates most cell groups, except for gametes (Your Genome, 2017). The mechanism for replication initially begins with Interphase, which is followed by the four famous phases of Mitosis PMAT (Prophase, Metaphase, Anaphase, and Telophase). This division results in two daughter cells that have the same number of chromosomes as the parent cell. For example, when a parent cell in humans undergoes Mitotic cell division, the parent cell consists of 46 chromosomes and replicates into two identical daughter cells, which each have 46 chromosomes. A **chromosome** is a DNA molecule that contains genetic information necessary for an organism to develop and to maintain proper functioning. Mitosis is a critical part of advancement of cell life, and it includes detailed stages that create the process of cell replication.

**Mitosis - Prophase**

During Prophase, the first stage of Mitosis PMAT, the cell’s nucleus, which contains the genetic material, condenses into small chromosomes (Nature, 2017). Each chromosome is made up of two sister chromatids connected by a centromere. A **chromatid** is the name of one of the two portions of a chromosome that contains DNA. A chromosome can be visualized as an X-shaped molecule. Within Prophase, the other main characteristic of the stage is the formation of microtubules. **Microtubules** must first be created in the cytoplasm in order for cell migration, to the opposite poles of the cell, to take place. Once the microtubules have formed, the cell is ready to continue dividing and enters Metaphase.

**Mitosis - Metaphase**

During Metaphase, the second stage of Mitosis PMAT, the cell’s chromosomes begin aligning on an imaginary line in the middle of the cell, which is known as the **Metaphase Plate** (Your Genome, 2017). Microtubules attach to each chromatid, which helps direct the DNA molecules toward the opposite sides of the cell during separation. This step allows for proper segregation of the chromatids so that each new cell has the proper number of chromosomes. Once the attachment of microtubules has occurred, the cell is ready to enter Anaphase continue replicating.

**Mitosis - Anaphase**

During Anaphase, the third stage of Mitosis PMAT, the cell’s chromosomes begin to separate toward the edges of the cell. As the separation between chromatids increases, the attached microtubules bind into the cell membrane to further the separation (Nature, 2017). The chromatids will continue to separate until they reach the edges of the cell, which is also known as the poles of the cell. This will end the Anaphase stage and Telophase will ensue.

**Mitosis -Telophase**

During **Telophase**, the final stage of Mitosis PMAT, the chromosomes reach the opposite poles. Telophase reverses the steps that previously occurred in Prophase. The chromosomes are released from the tight binding, a membrane begins to form around the new cell, and the microtubules disappear (Your Genome, 2017). This signals that the cell is ready to be pinched so that it can separate with identical chromosomes to parent through a process called **Cytokinesis**.

**Meiosis I - Round One of Division**

**Meiosis** is a cell division that replicates cells found in plants, animals, and fungi (Khan Academy, 2017). The type of cells that are duplicated are sperm and eggs, which are referred to as **gametes**. The replication mechanism starts the same way as Mitosis with Interphase; however, PMAT for Meiosis has different characteristics in each stage, and Meiosis is preformed twice resulting in four gamete cells. These gametes have half the number of chromosomes than the parent cell, which is why the cell is identified as **haploid**. For example, when Meiosis has completed both Meiotic cell division in humans, the 46 chromosomes of a parent cell will produce four haploid cells, which each consist of 23 chromosomes. Meiosis is an important cell division that allows for diversity among organisms created through new combinations of parent chromosomes after fertilization.

**Meiosis I - Prophase I**

In the **Prophase I** stage of Meiosis PMAT, chromosomes pair up with another chromosome. This association between chromatids allows for potential genetic recombination. **Genetic Recombination** is the process by which portions of DNA on one chromosome mix with another DNA molecule to increase variation (Khan Academy, 2017). The glue structure that holds the chromosomes together while pairing up is called the **chiasmata**. At the end of Prophase I, microtubules form and attach to a pair of chromatids, which is different from attachment to single chromatids in Mitosis. The cell then enters Metaphase I to continue division.

**Meiosis I - Metaphase I**

In the **Metaphase I** stage of Meiosis PMAT, the chromosomes line up on the Metaphase Plate. This alignment in the middle of the cell is similar to Mitosis, but the main difference is that there is a pair of chromosomes aligning on each side of the plate. The best way to visual this is to imagine a boundary down the center of this page with an X-letter on each side of the line. The other main characteristic of Metaphase I is the chromosome order on the Metaphase Plate is random, which increases the genetic diversity when the separation occurs (Your Genome, 2017).

**Meiosis I - Anaphase I**

In the **Anaphase I** stage of Meiosis PMAT, the chromosome pairs begin to separate by one chromosome being pulled toward the opposite pole (Khan Academy, 2017). As the chromosome is pulled further away from the middle of the cell, the X-shaped molecule does not split. The chromosomes will continue to separate from the alignment until it has reached the opposite pole of the cell.

**Meiosis I - Telophase I**

In the **Telophase I** stage of Meiosis PMAT, the DNA molecules decondense, but the cell will undergo another round of Meiosis. This future division causes the cell to not expand the DNA extensively. Telophase I will typically occur at the same time as cytokinesis to create two daughter haploid cells (Your Genome, 2017).

**Meiosis II - Round Two of Division**

Meiosis II combines the processes of Mitosis and Meiosis I by taking the two haploid daughter cells created in Meiosis I and duplicating them through Mitosis (Khan Academy, 2017). The two gamete cells condense their DNA and microtubules form in **Prophase II**. In **Metaphase II**, the chromosomes line up on the metaphase plate individually. This is a Mitotic process because when the separation occurs the chromosomes are split into single chromatids. During **Anaphase II**, the chromatids are pulled to the opposite poles, which can be visualized as an X-shaped molecule being split down the middle by a line and pulled apart. During **Telophase II**, the chromosomes decondense, and a new membrane begins to form around the chromatids at the poles. Cytokinesis will pinch off the cells resulting in four daughter cells that each have one chromatid. This means each daughter cell will have half the number of chromosomes as the parent cell.

**Conclusion**

Cell division plays an important role in maintaining and developing an organism. The two types of replication that are happening within your body are Mitosis and Meiosis. Mitosis is a broader cell replication that occurs in almost all cell types and organisms. This division results in two daughter cells consisting of the same number of chromosomes as the parent cell. This cycle only divides the cell once, and it is imperative for cell renewal. The second type of cell division is Meiosis, which is slightly more complex. This replication requires two rounds of division that produces four haploid cells per parent cell division. Meiosis helps increase the diversity of our genes and produce cells with correct chromosome numbers from sexual reproduction. Even though you cannot see your cells dividing, they are separating from Mitosis continuously, and you would not have been born without Meiosis!

**Chapter Glossary of Terms:**

**Mitosis –** Two identical daughter cells are produced from single parent cell.

**Meiosis –** Four daughter cells are produced from a parent cell after sexual reproduction resulting in half the number of chromosomes as parent cell.

**Chromosome** - DNA molecule that contains the genetic information.

**Microtubules** – Present in cytoplasm of cells which helps with cell migration to separate chromosomes during cell division.

**Metaphase Plate** – Imaginary plate formed during cell division, which is the location at which chromosomes align before separating to opposite poles.

**Chromatid** - One of the two portions of a chromosome that contain DNA.

**Cytokinesis** – Process that completes cell division after Mitosis by pinching off newly developed cell from parent cell.

**Haploid** – Daughter cell with half the set of chromosomes derived from parent cell.

**Genetic Recombination -** Process where portions of DNA on one chromosome mix with another chromosome to increase gene variation.

**Prophase I** – Chromosomes pair up for genetic recombination.

**Metaphase I** – Chromosomes align on both sides of metaphase plate.

**Anaphase I** – Chromosome pairs are pulled to the opposite poles.

**Telophase I** – Chromosomes decondense for two haploid cell products.

**Prophase II** – Two daughter haploid cells condense DNA and microtubules form.

**Metaphase II** – Two daughter haploid cells lineup on metaphase plate in pairs so there is a chromosome on each side of plate.

**Anaphase II** – Chromatids are pulled to the opposite poles as a pair of chromosomes.

**Telophase II** – Chromosomes decondense and new membrane forms for the new haploid cells.

**Reference**

Your Genome. (2017). *Mitosis versus Meiosis*. <https://www.yourgenome.org/facts/mitosis-versus-meiosis>

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