Meiosis and Mitosis

Lecture Objectives:

1. Differentiate mitosis from meiosis.

2. Describe how chromosomes replicate during mitosis and meiosis.

3. Describe how meiosis facilitates the three major features of Mendelian genetics: segregation, independent assortment and genetic recombination.

4. Explain the medical consequences that result from errors in cell division 5. Identify the origins of errors in cell division.

I. An Overview of Mitosis & Meiosis
   A. Cell Division
      1. Mitosis
      2. Meiosis
   B. Cell Division Definitions
      1. Mitosis occurs during cell division of somatic cells. A diploid parent cell generates two identical diploid daughter cells. Normally, recombination (discussed later) does not take place.
      2. Meiosis is the process by which sex cells (gametes) are formed. A diploid progenitor cell generates four haploid gametes.
         a. There are two cell divisions but only one doubling of the chromosomes.
            i. The process ultimately results in halving the amount of genetic material in the gametes, from 46 (diploid) to 23 (haploid) in the mature egg or sperm. One chromosome in each pair of homologous chromosomes in the parent cell will be allocated at random into each of the daughter cells. Thus, the normal egg and sperm each contain 23 chromosomes intermixed of differing parental origin. When they unite at fertilization, there will again be 46 chromosomes in the fertilized egg. Recombination is frequent during meiosis.

II. Definitions and Cell Machinery
   A. Chromosomes
      1. Chromosomes are the structures that hold all the genetic material. They are rod shaped condensations of nucleic material (DNA) and come in different sizes. Each has unique characteristics which allows us to differentiate one from the other.
      2. Chromosomes, like genes, come in pairs - ideally, exactly half the chromosomal material – one member of each pair – came from each parent. T
   B. Centromere
      1. The constriction of the chromosome, which in the center of all the action during cell division, is called the centromere.
      2. After DNA replication, each chromosome has two identical sister chromatids.

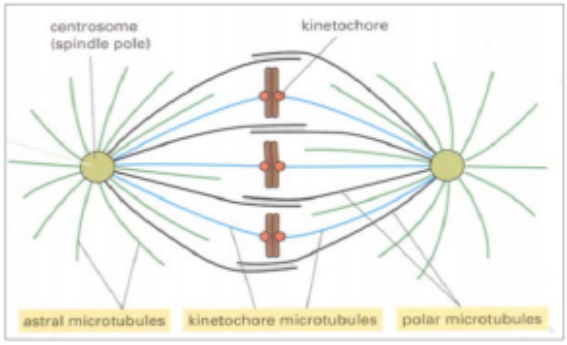
C. Kinetochore

1. The kinetochore is a protein structure that forms on the centromere to which the microtubules, literally the workhorses in cell division, attach. There are three types of microtubules that function as part of the mitotic spindle apparatus.

2. The kinetochore microtubules attach to the kinetochore at the centromere. They are responsible for pulling the sister chromatids of each chromosome apart at the end of metaphase.

   a. The polar microtubules overlap in the midline and are responsible for pushing the poles of the spindle apparatus a part. The astral microtubules radiate in all directions from the centrosomes and aid in spindle orientation immediately before mitosis.

Image 1:



   b. The centrosomes consist of two centrioles and are the organelles that are the primary microtubular organizing center that splits and forms the spindle apparatus.

D. Cell Cycle Review

1. Mitosis is actually the shortest of the four stages of the cell cycle. Immediately after mitosis, if a cell is destined to divide again, it enters Gap 1 or G1 where there is no DNA synthesis. If a cell is not destined to divide again, it enters G0. Some cells spend a very long time in G1 – days or even years; others pass through G1 in a matter of hours.

2. G1 is followed by the
S phase, the stage of DNA synthesis where the DNA molecule replicates and is followed by a further gap in time waiting for mitosis to begin. By the end of S phase, the DNA content of the cell has doubled, and during the next phase, Gap 2 or G2, each chromosome consists of two identical DNA molecules, the sister chromatids.

   a. During G2, essential proteins and cofactors are produced necessary for mitosis to occur. G2 is ended by mitosis.