Study Guide - Meiosis (Sexual Reproduction)

In previous lessons we have talked of sexual reproduction as being reproduction where two parents (generally one maternal and one paternal) that join together to from a new different individual. As part of sexual reproduction the offspring of such a union obtains the traits or characteristics (for example, height, hair color, and eye color, etc.). This type of information is found on the chromosome in specific parts called **genes**. Genes offer the chance of diversity. There are pairs of genes on every chromosome. These pairs of genes are called **alleles**. Alleles are genes that identify a specific trait and offer different forms for that trait. Because the genes have come from two different parents, it is possible that the alleles for hair color are different - one could be for black hair and the other could be for blonde hair. Basically it means that through sexual reproduction, the offspring can end up with new combinations of alleles, and these lead to variations in their traits - not exact copies.

Remember that in asexual reproduction, the offspring are virtually identical copies of the parent cell - because they are simply a division of that parent cell. In this lesson we will see how sexual reproduction provides for diversity through a process called meiosis.

Meiosis vs Mitosis

Remember in our last lesson that we talked about mitosis, which took a parent cell and produced two virtually identical daughter cells. In meiosis, the cells are divided not once, but twice. The whole process serves to take one **diploid** cell and produces four **haploid** cells. That is to perform a process of reduction-division. Throughout this lesson we are going to refer to the process of meiosis in humans so we can keep track of the numbers of chromosomes. Meiosis occurs in the reproductive structures and organs - that would be the testes for males and the ovaries for females.

Lets look at meiosis this way. Well take two humans, a man and a woman. Each cell in each of these people contains 46 chromosomes (also called **diploid cells**). They want to produce a child, which will have the same amount of chromosomes as they do - 46. Since humans reproduce sexually instead of just splitting (like organisms that reproduce asexually), the mans and the womans cells have to join - if they were to do that without having something that performed a **reduction-division** process, their offspring would have 92 chromosomes and that would just continually multiply with every generation. So, the reproductive structures and organs contain **germ cells** that go through the process of meiosis - which we have already seen takes the normal 46 chromosome cell and reduces it to 23 (called **haploid**) chromosomes. Now, since this happens in the man and the woman - they both have **gametes** (**eggs** and **sperm**) that have 23 chromosomes each - so when they come together in a process called **fertilization**, they form what is called a **zygote** that contains 46 chromosomes and is the beginning of a new life.

Now lets look at **meiosis** - the **reduction-division** process that produces the haploid cells. To do so, it is important that we understand the meaning of two words - **diploid** and **haploid**. Remember that there is a special way that we use to refer to these numbers using the $2n$ for diploid and *n* for haploid. The *n* stands for the number of chromosomes in a cell. So if a haploid human sperm cell has 23 chromosomes (which would be = to *n*) then 2 times that number would give us the amount of chromosomes in a diploid human cell, which is 46.

Meiosis

When we talked of mitosis we mentioned the **cell cycle** - that is no different for **sex cells**. They also follow a similar cell cycle with the major difference being that they do everything twice - that is: **interphase**, **prophase, metaphase, anaphase, and telophase**. These are divided into what we will call **meiosis I & II**. And remember that as we go through this, we will keep track of the number of chromosomes at each stage so we can see the reduction-division.

Interphase I

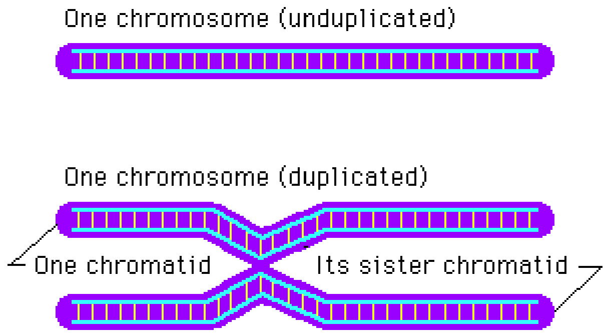
Remember that interphase is the period in the cell cycle when DNA is replicated (duplicated) and the cell grows and performs its other necessary functions. The same takes place in interphase I. The DNA in the chromosomes is duplicated so that a cell with 46 chromosomes (in humans) will have a total of 92 chromosomes. Once this has taken place, the cell moves into prophase I.

Meiosis I

The first major subdivision.

Prophase I

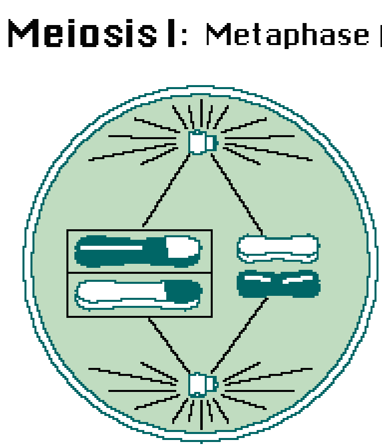
In **prophase I** the chromatin shortens and becomes threadlike (if observed with a microscope). The **chromatin** forms



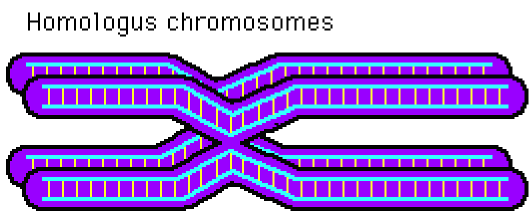
chromatids which in turn form up in pairs (like in mitosis) called **sister chromatids**. Because of the DNA duplication that took place in **interphase I** though, there are two pairs of sister chromatids. Lets keep track of the numbers were dealing with here - sister chromatids contain two strands joined at the **centromere**, so a pair of sister chromatids would contain four strands. In prophase I, these pairs of sister chromatids join in a process called **synapsis** into what we call a **tetrad**. The interesting thing is though that not just any sister chromatids pair up. They pair with chromosomes called **homologous chromosomes**. These homologous pairs are similar in length and size, as well as the genes that they carry. Once these homologous pairs are together a very important event takes place. The event is called **crossing over** and it is the process by which segments of DNA from one chromatid in the tetrad are passed to another chromatid within the tetrad. This provides for a genetically different combination than the original chromatids had.

The Prophase I also sees the disappearance of the nuclear envelope an the nucleolus. And there is still one cell with 92 chromosomes in it.

Metaphase I

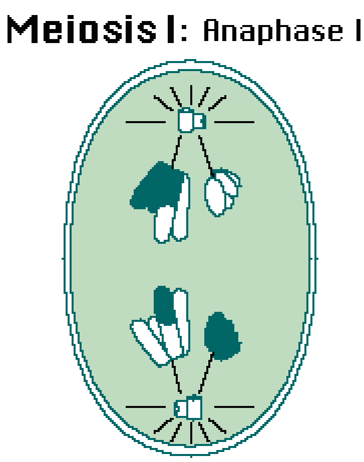


In **metaphase I**, the pairs of **homologous chromosomes** (**tetrads**)



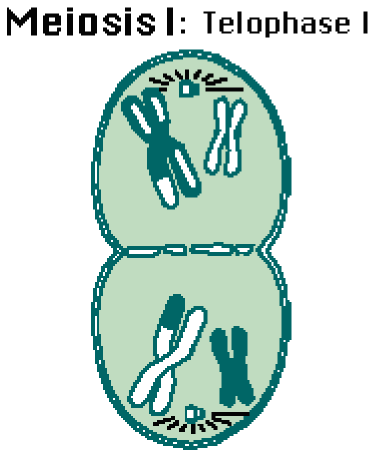
line up at the **equatorial plate** and **spindle fibers** attach to the centromeres. Still 92 chromosomes

Anaphase I



In **anaphase I**, the first **reduction-division** occurs. The pairs of **homologous chromosomes** (**tetrads**) are separated and one homologous pair moves to each side of the cell. The result is that each side of the cell now has 46 chromosomes. So the number is halved.

Telophase I



In **telophase I**, the nucleolus begins to reorganize, the chromosomes become chromatin, and cytoplasmic division takes place producing two cells. **Each cell contains 46 chromosomes**.

Results of Meiosis I

At the **beginning of meiosis I we had one cell**. At **the end we have two diploid cells** (each containing 46 chromosomes) that are passed on to **Meiosis II**.

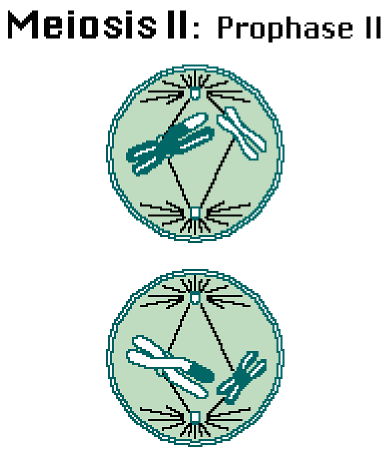
Interphase II

No DNA duplication takes place.

Meiosis II

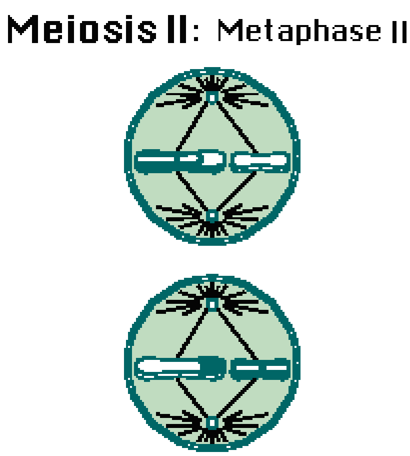
The second major subdivision. Remember that **two diploid cells enter this process**, so even though we just talk about the events happening in one cell, it is actually happening simultaneously in another cell.

Prophase II



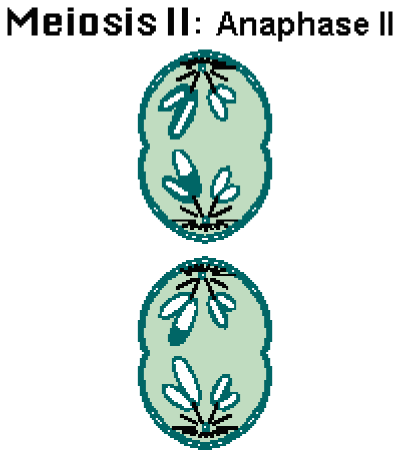
Chromatin condenses and forms chromosomes that consist of **sister chromatids** joined at the **centromere**.   There are **46** chromosomes here.

Metaphase II



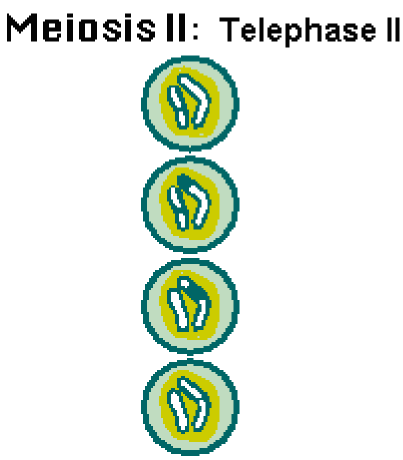
The **sister chromatids** line up at the **equatorial plate** with **spindle fibers** attaching to the **centromere**.   There are still **46** chromosomes in the individual cells.

Anaphase II



Here the centromeres divide and the chromosomes separate from each other and move toward opposite ends of the cell. The **second reduction-division** takes place and **there are now 23 chromosomes in each end of the cell**.

Telophase II



23 chromosomes are gathered at the poles of the cell and they begin to form back into chromatin. The nuclear envelope develops, the nucleolus reappears, and the cytoplasm is divided **forming two different cells**. **These cells are haploid cells containing 23 chromosomes**.

Results of Meiosis II

Since we had **two diploid cells** that entered this process, the reduction-division that takes place **produces 4 haploid cells** (23 chromosomes each).