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Meosis – Splitting More Than Hairs

This process differs from normal cellular regeneration (Mitosis) during which new cells are made to build up, replace, or repair body tissue. Meiosis is reserved specifically for gametes, or the reproductive cells, and the process literally cleaves double-helix strands of DNA into two, resulting in sets of single stranded DNA, or 23 unpaired chromosomes. Human DNA contains 46 chromosomes paired in a unique sequence—23 from the mother, and 23 from the father, fused together to create a new human, with the final pair determining gender. In order to produce a unique human being from two other human beings, the originating germ cells, or gametes, *must* contain only half the required "recipe", else fusion of the sperm and the egg would attempt to create what could only be described as something quite non-human—and such a mutation would not be permitted to survive in the womb. Considering that just one mutant gene out of the 30,000 or so genes that make up a human being may sometimes mean the difference between life and death, it isn't difficult to imagine how very delicate this process is, nor how very disastrous it could be if a fetus *were* to be created with two full sets of chromosomes. Figure 1 illustrates (loosely) the meiotic division of cells into those necessary for eventual fertilization and the creation of a new human being.

More than a little difficult to describe, but for the purposes of the explanation, meiosis is presented in phases and steps in Table 1 to illustrate some of the details of this DNA "unzipping" for the preparation of new life. For the initial explanation, we'll use spermatogenesis. Starting with a single, whole cell, the reproductive cell first undergoes a mitotic division to replicate itself (one cell remains as the 'germinal line' at the basement membrane of the seminiferous tubule within the testes, while the other one (created through mitosis) becomes the primary spermatocyte). The primary spermatocyte then undergoes two meiotic divisions in order to replicate and then unpair its chromosomes, resulting in the creation of four haploid spermatids. These then morph into motile sperm within the tubules of the epididymis.

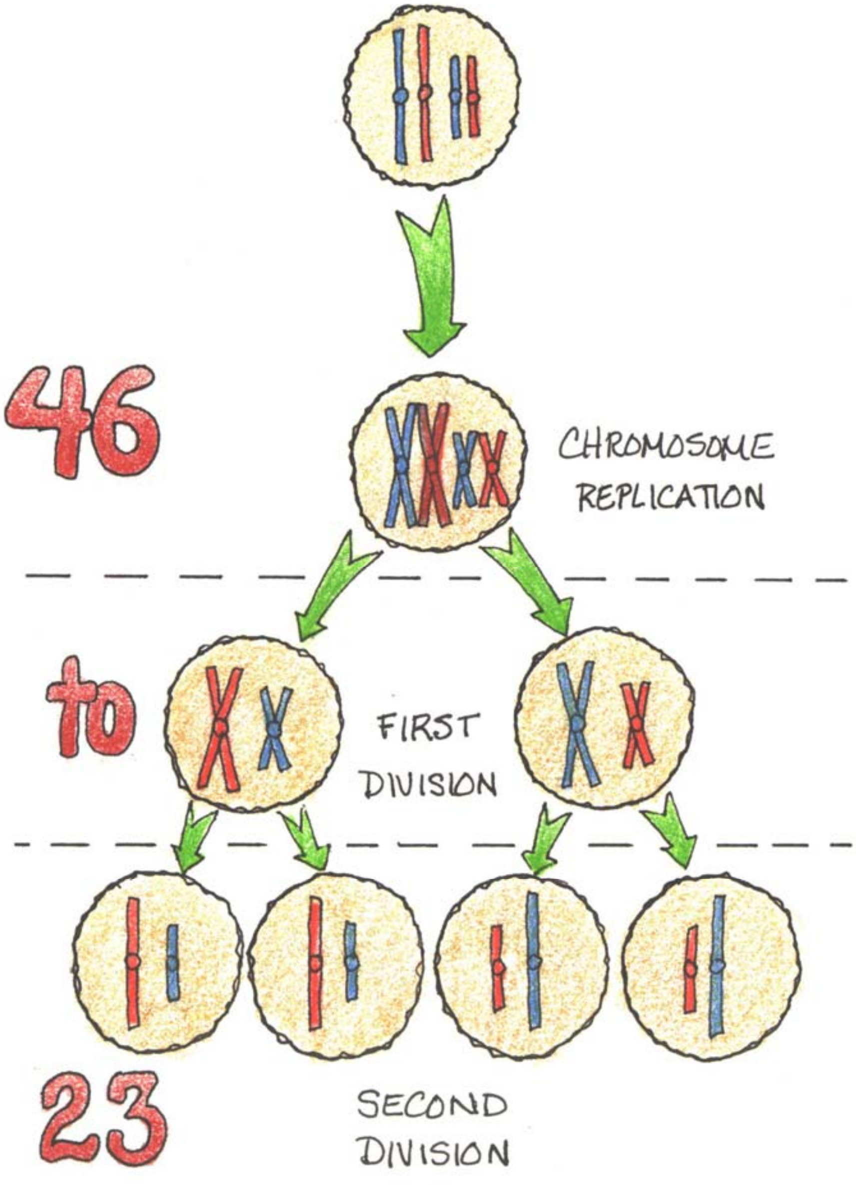

Figure 1: Meiosis

		First Division		Second Division
Interphase		Chromosomes replicate, forming 4-strand bundles joined together by a centromere (chromatids).		
Prophase	I	Chromosomes become distinct; chromatids remain joined by centromere. Homologous chromosomes move close together, intertwine, and *may exchange genetic information* (crossing over). This is how you might get your father's eyes, but your paternal grandmother's nose! Spindle fibers appear as centrioles separate.	II	Nuclear membrane disappears; spindle fibers form again and double-stranded chromosomes appear as thin threads.
Metaphase	I	Pairs of synaptic chromosomes line up along the metaphase plate (equator) and spindle fibers attach to each pair, preparing for separation.	II	Chromosomes line up again, centromeres replicate.
Anaphase	I	Synaptic pairs separate and spindle fibers pull the homologous chromosomes to opposite sides of the cell (at this point, chromatids are undivided and still attached by centromere).	II	Chromatids separate – each is now a single strand. Migrate to opposite ends of cell.
Telophase	I	Nuclear membrane forms around each end, cytoplasm compresses, dividing cell in half.	II	Nuclear membrane forms around each group; cytoplasm compresses, dividing cell in half again, each now containing the haploid number of chromosomes, all genetically different than the parent cell.
Interkinesis		Nucleus and its membrane well-defined. Each chromosome consists of two chromatids that will not replicate on the next division.		

Table 1: Meiotic Divisions and Phases

The timing and some of the details of this process are a bit different in a female to create ova, or eggs. Beginning in the embryonic stages of development, oogenesis starts by the mitotic replication of oogonia (eggs) to form primary oocytes, each containing the diploid number of chromosomes. The primary oocytes undergo only Prophase I at this point, forming primordial follicles that will remain dormant until the female reaches puberty. In the fetus, there are approximately 3 million primary follicles per ovary and by birth this is already reduced to about 1 million. By puberty, there are about 100,000 left and this loss (atresia) will continue even as the ovaries begin to release eggs at the rate of about 1 per month (around 1% of the monthly cycles may result in development of multiple follicles, producing two or more fraternal fetuses.). A female with a normal cycle will release only about 500 eggs in her entire lifetime.

At the beginning of the woman's cycle, a follicle will 'wake up' and begin to grow, reaching a mature size of about 2cm. Just before ovulation, the first meiotic division completes itself, forming a haploid oocyte and one polar body. The second division starts, but goes dormant again at Metaphase II, where it will remain until after ovulation and fertilization. Only upon fertilization will it complete the final division, fusing with the sperm, forming the female pro-nucleus and casting off its final polar body.

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