Cell Reproduction and Conception

Most human cells are frequently reproduced and replaced during the life of an individual. However, the process varies with the kind of cell. **Somatic**, or body cells, such as those that make up skin, hair, and muscle, are duplicated by **mitosis**. The **sex cells**, sperm and ova, are produced by **meiosis** in special tissues of male testes and female ovaries. Since the vast majority of our cells are somatic, mitosis is the most common form of cell replication.

**Mitosis**

The cell division process that produces new cells for growth, repair, and the general replacement of older cells is called mitosis. In this process, a somatic cell divides into two complete new cells that are identical to the original one. Human somatic cells go through the 6 phases of mitosis in 1/2 to 1 1/2 hours, depending on the kind of tissue being duplicated.
Some human somatic cells are frequently replaced by new ones and other cells are rarely duplicated. Hair, skin, fingernails, taste buds, and the stomach's protective lining are replaced constantly and at a rapid rate throughout our lives. In contrast, brain and nerve cells in the central nervous system are rarely produced after we are a few months old. Subsequently, if they are destroyed later, the loss is usually permanent, as in the case of paraplegics. Liver cells usually do not reproduce after an individual has finished growing and are not replaced except when there is an injury. Red blood cells are also somewhat of an exception. While they are being constantly produced in our bone marrow, the specialized cells from which they come do not have nuclei nor do the red blood cells themselves.

**Meiosis**

Meiosis is a somewhat similar but more complex process than mitosis. This is especially true in females. While mitosis produces 2 daughter cells from each parent cell, meiosis results in 4 sex cells, or gametes in males and 1 in females. Unlike the cells created by mitosis, gametes are not identical to the parent cells. In males, meiosis is referred to as spermatogenesis because sperm cells are produced. In females, it is called oögenesis because ova, or eggs, are the main ultimate product. The illustration below shows the 8 phases of spermatogenesis.

![Phases of spermatogenesis](http://anthro.palomar.edu/biobasis/bio_2.htm)
Conception

Sperm carries the father's chromosomes to the mother's ovum where they combine with her chromosomes at the time of conception. Sperm cells are microscopic, but ova may be large enough in some species to be visible with the naked eye. Human ova are about the diameter of a hair.

The two sequential division processes of meiosis culminate in the production of gametes with only half the number of chromosomes of somatic cells. As a result, human sperm and ova each have only 23 single-stranded chromosomes.
Human somatic cells, with their full set of 46 chromosomes, have what geneticists refer to as a **diploid** number of chromosomes. Gametes have a **haploid** number (23). When conception occurs, a human sperm and ovum combine their chromosomes to make a **zygote** (fertilized egg) with 46 chromosomes. This is the same number that the parents each had in their somatic cells. In doing this, nature is acting conservatively. Each generation inherits the same number of chromosomes. Without reducing their number by half in meiosis first, each new generation would have double the number of chromosomes in their cells as the previous one. Within only 15 generations, humans would have over 1½ million chromosomes per cell and would be a radically different kind of animal. In fact, when a zygote has an extra set of chromosomes, it usually is spontaneously aborted by the mother's reproductive system--it is a lethal condition.

The complete meiosis process in human males takes about 74 hours. Spermatogenesis usually begins at 12-13 years of age and continues throughout life. Several hundred million sperm cells are produced daily by healthy young adult males. Between 200 and 600 million sperm cells are normally released in each ejaculation. Since only one sperm cell is required for conception, this huge number would seem to be an extreme overkill. However, as many as 20% of sperm cells are likely to be defective and the female reproductive tract is hostile even to healthy ones--it is acidic and contains antibodies that seek out and destroy the sperm cells. Ejaculating large numbers of sperm at the same time is nature's way of overcoming these difficulties and increasing the likelihood that conception will take place. The number of sperm cells produced can be significantly diminished by psychological and physiological stress. Sperm count also progressively declines with age after reaching a peak, usually in the early 20's. In addition, the percentage of sperm that move randomly rather than in a straight line generally increases in older men. The result is a decrease in male fertility. The genes that are responsible for sperm production are in the Y sex chromosome. Unfortunately, the mutation rate for the Y chromosome is
thought to be thousands of times higher than for those in other chromosomes. This may be a major cause of male infertility. As a result, genetic testing is beginning to be used to diagnose it.

Meiosis in human females is more complex. By the 5th month after conception, immature sex cells begin to develop in the fetal ovaries but stop at an early stage of meiosis (after prophase I). They remain in this precursor egg cell, or primary oöcyte, phase until puberty when hormones cause a resumption of meiosis for one to several cells each month. They proceed to the 1st and 2nd reduction divisions and once again stop developing. At this stage they are secondary oöcytes. When a secondary oöcyte is finally released from the ovaries into the fallopian tube (during ovulation), the egg still has not completed the last stage of meiosis. That happens only at conception as a result of chemical changes that occur when the main part of a sperm cell enters the ovum.

Virtually all (99.9%) sex cells in a woman's ovaries never develop beyond the primary oöcyte stage and eventually are reabsorbed by her body. By 20 weeks after conception, there are approximately 7,000,000 primary oöcytes. All but about 1,200,000 are lost by birth. At puberty, there are only around 400,000 of them remaining. Throughout life, there is a constant decline in the number of potential eggs. Each time one is successfully ovulated, as many as 2000 are lost. Normally, women have on average 11-14 ovulations per year for 33-36 years. This means that less than 500 secondary oöcytes usually are produced out of the store of hundreds of thousands of primary oöcytes. The actual number of ovulations is highly variable and often much lower since the process is governed by hormones and ultimately other factors including psychological stress, nutrition, physical activity, and pathological conditions. The fact that women rarely have more than a few children is evidence that only a small fraction of the successfully ovulated eggs are fertilized and become viable zygotes. Beginning about age 27, a woman's fertility progressively declines. Around 35-37 years old, the decline becomes much steeper and the chances of conception significantly lower. By the early 50's, most women begin the transition to menopause when they stop ovulating altogether. The temporary cessation of ovulation and subsequent infertility can occur much earlier in life as a result of reduced blood estrogen levels caused by excessive physical activity. This is very likely the reason that roughly a quarter of American women athletes in high school and college cease having menstrual periods. It also results in a significant decrease in their bone density.
NOTE: Humans may be the only animal species in which females now normally live for many years following menopause. Freed from having more children themselves, human grandmothers are in a position to assist their own daughters and sons in rearing their offspring. This potentially increases the chances that grandchildren will survive, thereby giving our species an advantage over other animals in the competition for survival. However, people rarely lived beyond menopause until a little over a century ago when modern medicine and other technological advances made it possible. Prior to that time, we were more often like other animals in that most of us succumbed to disease, accidents, or predators before middle age and menopause.

NOTE: On-going research suggests that it may be possible within a few years to return fertility to post menopausal women by stimulating stem cells in their ovaries to produce new eggs.

Study Suggests Way To Create New Eggs In Women--National Public Radio audio report on February 27, 2012.

To return here, you must click the "back" button on your browser program. (4 mins, 3 secs)

When human sexual intercourse occurs, it takes about 5 minutes for sperm to reach the upper end of the fallopian tubes where conception usually takes place. Of the several hundred million sperm cells that enter a vagina, rarely do more than a few hundred successfully pass through the cervix and uterus. Only about 100 reach the upper end of the fallopian tubes. Sperm cells are guided over this path mostly by heat sensing. The upper ends of the fallopian tubes are about two degrees warmer than the lower ends. Secondary oöcytes secrete chemicals that also may guide sperm cells to them when they are in close proximity. Usually, only the most viable sperm cells reach the secondary oöcytes and play their part in conception. Those sperm that fail in this competition are often genetically abnormal. The endurance test that they must go through in the female reproductive tract is nature's way of eliminating these poorer specimens.

Among humans, fertilization usually occurs within a day after ovulation. It takes about 4 days for secondary oöcytes to pass through the fallopian tube in their journey to the uterus. Conception must occur early in this process. Sperm usually can remain viable for up to 48 hours in the female reproductive tract, but secondary oöcytes remain viable for only about 24 hours after they have left the ovaries. This means that sexual intercourse must occur from a few days before to one day after ovulation if
conception is desired. In most non-human mammals, birds, reptiles, fish, and insects, fertilization is made more likely by the fact that females are sexually receptive only around the time of ovulation. This period of female sexual receptivity is called estrus. In most species, it is common for all females to have their ovulations around the same time of year. This reproductive synchronization results in a common mating season. In humans and some other primates, sexuality is far less related to the timing of ovulation. Among these species, there is no mating season. More precisely, the entire year is a mating season since they have a more or less chronic interest in sex. This is another way in which nature has chosen to increase the likelihood of conception.

Half of the sperm cells produced normally carry the X-chromosome and half have the Y-chromosome. Subsequently, we would expect that 50% of human babies would be males and 50% females, but this usually is not the case. The ratio of male to female newborns in the U.S. and most of the world is 105-110 males to 100 females. The ratio of males to females at conception is generally even higher than it is at birth. This is fortunate in the long run for society because male spontaneous abortions and infant mortality rates are higher. In addition, males are more likely to die from accidents and combat as teenagers and young men. Males in developed nations who survive to adulthood also can expect to die at a younger age than women.

**Male-Female Ratios in the United States**

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<thead>
<tr>
<th></th>
<th>Males</th>
<th>Females</th>
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<tr>
<td>at conception</td>
<td>130-150</td>
<td>100</td>
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<tr>
<td>at birth</td>
<td>105-110</td>
<td>100</td>
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<tr>
<td>at age 20</td>
<td>98</td>
<td>100</td>
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<tr>
<td>at age 65+</td>
<td>68</td>
<td>100</td>
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Current cultural practices in China and India result in even higher rates of male births. Since 1979, China has had a national policy of allowing parents to have only one child in order to reduce population growth. A traditional preference for male children and the ready availability of ultrasound technology has led to large numbers of abortions of female fetuses. This occurs despite the fact that abortions for the purpose of preventing the birth of female children is illegal. There are now 119 boys born for every 100 girls in China, and in some regions the ratio is as high as 144 to 100. A consequence of this practice is the growing scarcity of marriageable women. As of the 2005 census, there were 32 million more young men than women in China. While India does not have a one child policy, it is facing a similar problem because of the selective abortion of female fetuses, especially in the more prosperous states of North India. This is driven by the economic difficulty of raising large families and the preference for male children. The huge excess of marriageable men in China and India could be socially and politically explosive in the near future.
In societies that encourage a form of marriage in which one man has more than one wife at the same time (polygyny), higher numbers of female children are usually born than in the predominantly monogamous nations. Why this reverse birth ratio pattern occurs is not entirely understood. However, it is very likely connected with the fact that each wife has less frequent sexual intercourse. Girls are more likely to be conceived when conception is close to the time of ovulation. When there is intercourse at other times as well, the sperm cells are more likely to be waiting for ovulation at the upper end of the fallopian tubes. They do not have as far to go to reach the egg.

Why Twins?

Multiple births at the same time are rare for humans and most other primate species. Having fraternal, but not identical, twins apparently runs in family lines, and is also somewhat more likely for women over age 30.

Fraternal twins may look similar but are not genetically identical. In fact they are no more identical than any brother or sister. They share their mother's uterus during gestation but come from two different eggs fertilized with different sperm. Subsequently, they are called dizygotic twins 🤼. In contrast, identical twins are mostly identical genetically because they result from one zygote splitting into two or more separate ones within a few days after conception. As a consequence, they are called monozygotic twins 🤰️. If the division of the original zygote does not occur until the 9th to the 12th day after conception, the monozygotic twins are likely to be mirror twins. That is, they will have small mirror image differences internally and externally. For instance, one may be left handed and the other right handed. Likewise, the cowlick in their hair at the back of the head will be on opposite sides. If the division of the zygote occurs after day 13, the monozygotic twins are likely to be born conjoined.

Any differences between monozygotic twins later in life are mostly the result of environmental influences rather than genetic inheritance. However, monozygotic twins may not share all of the same sequences of mitochondrial DNA. This is due to the fact that the mitochondria in a cell may have somewhat different versions of DNA, and the mitochondria can be dispersed unequally when a zygote fissions. Female
monozygotic twins can also differ because of differences between them in X-chromosome inactivation. Subsequently, one female twin can have an X-linked condition such as muscular dystrophy and the other twin can be free of it.

NOTE: X-chromosome inactivation in females was described at the end of the first topic section of this tutorial ("Basic Cell Structures") and mitochondrial DNA is described in the last topic section ("Molecular Level of Genetics").

There has been at least one recorded instance of twins who are identical on their mother's side but share only half of their father's genes. These "semi-identical" twins result from two sperm cells fertilizing the same egg. This double fertilization of an egg apparently occurs in about 1% of human conceptions. In most cases, the embryo is not viable and dies.

Dizygotic twins can also be produced when a woman has sexual intercourse with more than one man around the time she is ovulating. If multiple viable eggs are released from her ovaries, each can be fertilized by sperm from a different man. This is referred to as heteropaternity.

Why Hermaphrodites?

Normally in humans one sperm cell combines its chromosomes with those of one ovum at conception and that in turn develops into a single embryo that will become a fetus. Very rarely, however, two zygotes fuse and become a single embryo. If it survives gestation, a baby will be born who is a true chimera—it is genetically two "people" in one body. If those two "people" are not the same gender, the baby will likely be a hermaphrodite—it will have both male and female sex organs and other body tissues. Some researchers believe that the frequency of chimeras being born will be increasing as in vitro fertilization becomes more common since two or more embryos are usually placed in the uterus with this procedure.

NEWS: On January 16, 2005, a 66 year old Romanian woman named Adriana Iliescu gave birth to a daughter. This makes her the oldest woman to become pregnant and deliver a live baby. She was implanted with a fertilized egg from a healthy younger woman. The baby was 6 weeks premature and weighed only 1.4 kilograms (3.1 pounds), which is less than half the normal newborn weight. Two other fetuses died
during the pregnancy (News at Nature.com, January 17, 2005).

**NEWS:** In the August 23, 2009 issue of *Biology Letters*, Kristen Navara of the University of Georgia presented the results of a 202 nation survey of data on male to female ratios at birth. She noted that there is a skewing of sex ratios that corresponds to latitude. In temperate and subarctic latitudes, there are slightly more boys born compared to tropical latitudes. Navara said that these differences were independent of cultural practices and the socio-economic status of families.