

The reproductive system

Reproduction

All living organisms reproduce. Reproduction is the process by which organisms generate new individuals of the same kind ensuring continuation of the species.

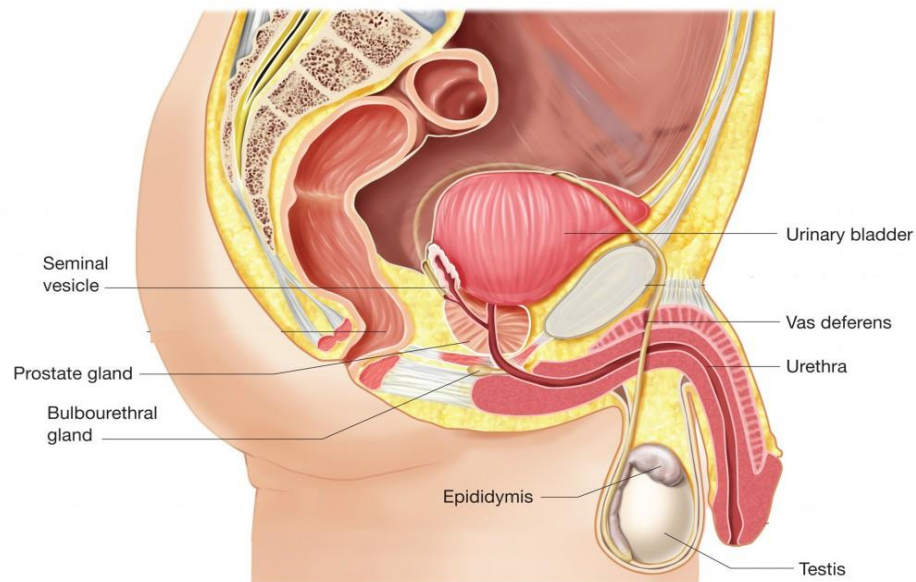
There are two types of reproduction: asexual and sexual. Humans have sexual reproduction.

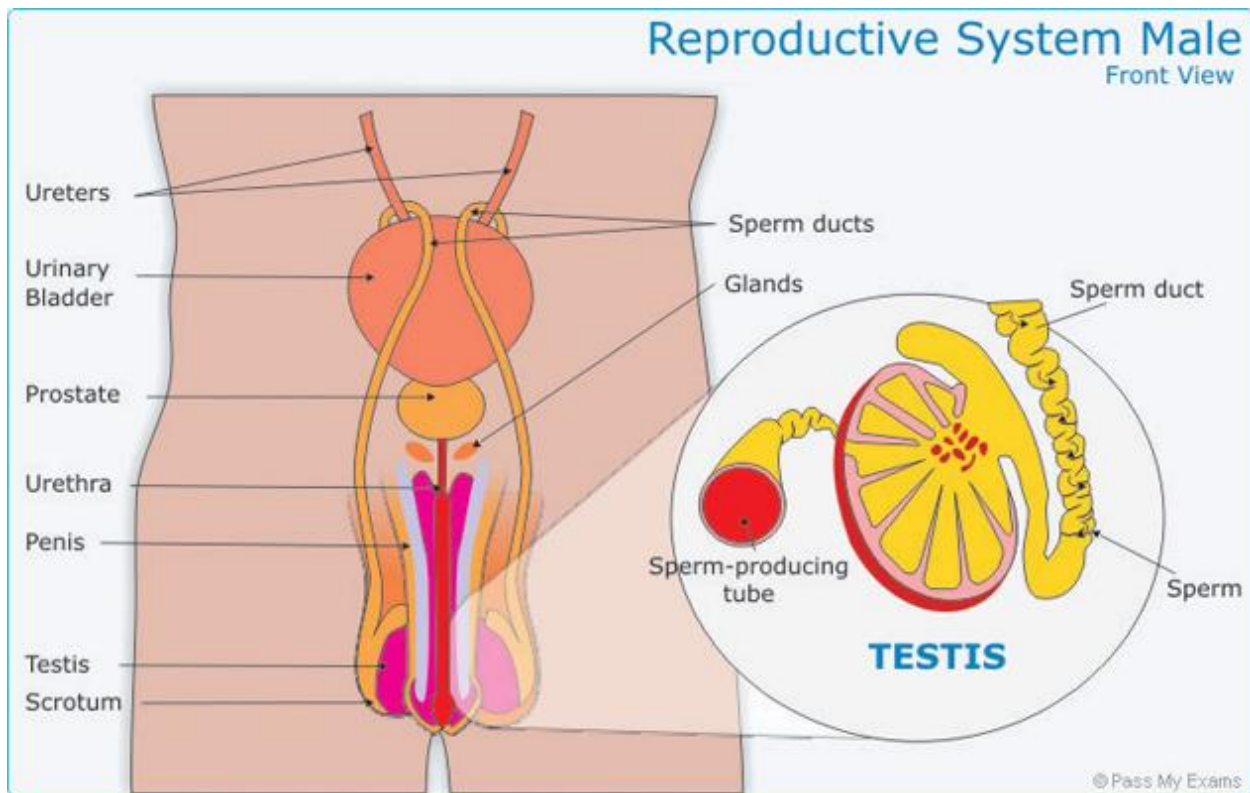
Sexual reproduction involves **two** parents. The parents have sex organs which produce sex cells or **gametes**. The male gamete is **sperm** and the female gamete is the **egg**.

Sexual reproduction is the fusion or fertilisation of the two male and female gametes to produce a fertilised egg or **zygote**. The fertilised egg goes on to divide many times to form a ball of cells. This grows into an **embryo** which eventually develops into a separate individual.

In humans, the organs involved in the production of the sex cells are called the **gonads**, the testicles in males, and the ovaries in females. Gonads also produce sex hormones.

Male reproductive system





Testicles

Male gonads are called **testicles**. These two organs are composed of numerous coiled **seminiferous tubules**, where we find the cells that produce the **spermatocytes** (precursors of sperm cells). Additionally, it is in the testicles where the male hormone, **testosterone**, is produced and released in the bloodstream.

The testicles are located outside the abdominal cavity (as spermatocytes are best developed at a temperature slightly lower than body temperature (37 °C)) inside a thin fold of the skin called the **scrotum**.

There are a series of tubular canals leading to the outside of the body, which transport and store the sperm refer to as **reproductive ducts**:

- **Epididymis:** **Spermatocytes** mature here becoming **sperm** (they are now ready for fertilisation). They now travel to the vas deferens.
- **Vas deferens:** It is the continuation/elongation of the epididymis and it is where sperm is stored. This tube will also transport the sperm from the epididymis to the urethra passing by the seminal vesicles and the prostate gland on its way out.

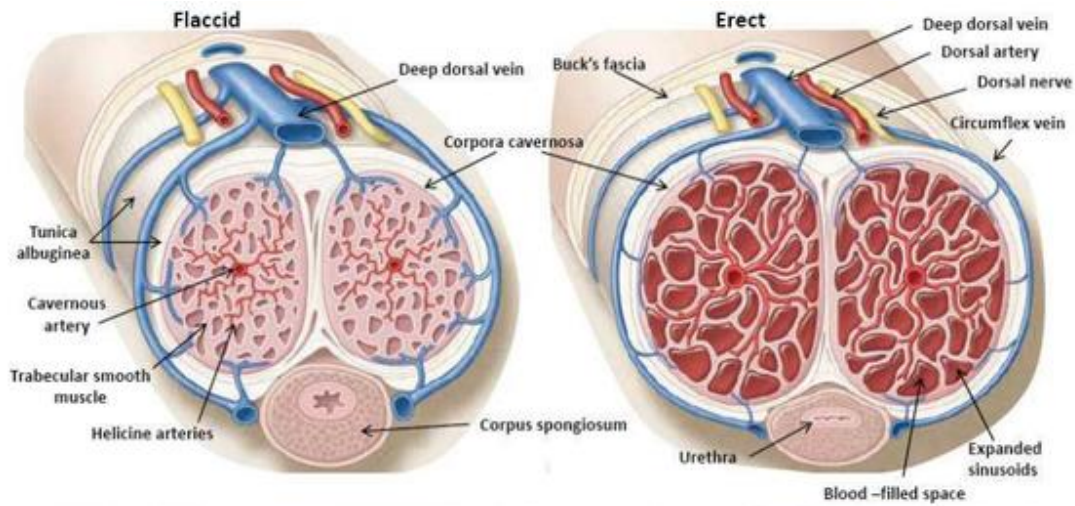
- **Urethra:** Part of both the excretory and the reproductive system. This tube expels both urine and semen from the body.

There are as well a number of glands that secrete substances that mix with the sperm to produce a fluid called **semen**.

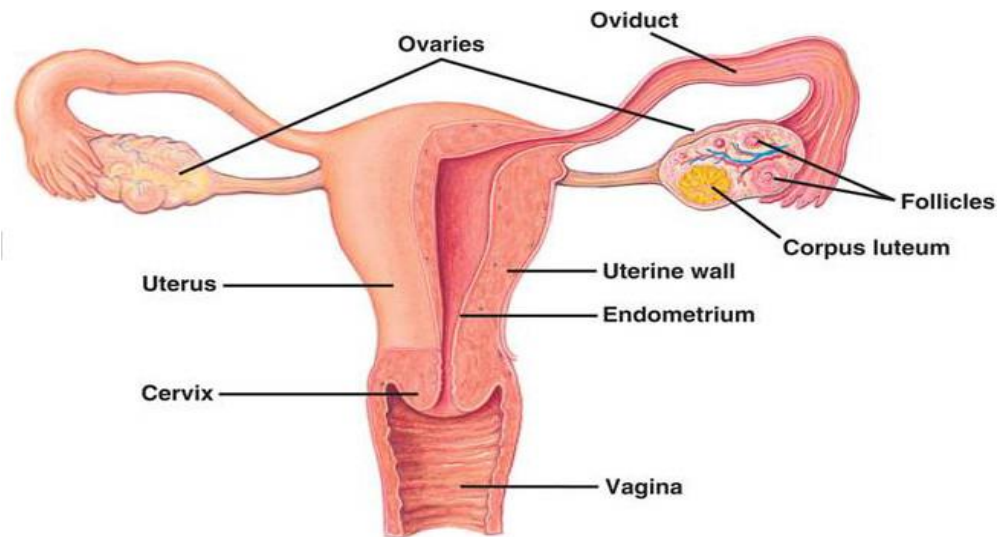
- **Seminal vesicle:** This gland is responsible for adding nutrients (glucose) to the semen
- **Prostate:** Its function is to add liquids to the semen.
- **Bulbourethral gland/Cowper's gland:** This gland adds a clear liquid to the urethra just before ejaculation known as the **pre-ejaculate**. Its function is to lubricate the urethra and prepare it for the semen to pass through.

Penis

This is the male organ that deposits semen (containing sperm) inside a woman's body during sexual intercourse. It contains two spongy masses of **erectile tissue** (the *corpora cavernosa*) on each side above the urethra.



Female reproductive system

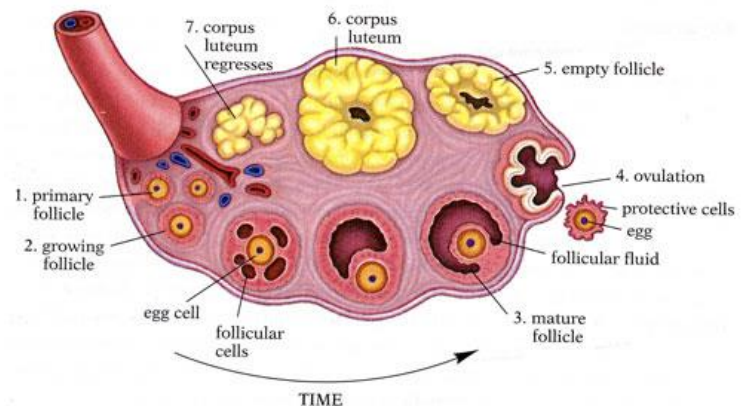


Ovaries

Female gonads are called **ovaries**. They are two of them found in the abdominal cavity (one on each side).

Here is where oogenesis occurs. On the external part of the ovary (the cortex) there are ovarian follicles. Each follicle contains one developing egg. The closer the follicles are to the ovary surface, the bigger they are. The closest ones (therefore biggest) are called Graafian follicles, each containing a mature egg that is ready to be released. Once a month an egg cell (ovum) is released as a reaction to different hormonal levels (see menstrual cycle).

The ovary also produces female sex hormones; oestrogen and progesterone



Follicle development

The **reproductive ducts** in females play a role in **fertilisation** and **gestation**:

Fallopian tubes (oviduct): Carries the ovum to the uterus. Fertilisation occurs in the first third of the fallopian tube.

Uterus (womb): This is where the fetus develops; gestation. During pregnancy the uterus increases its size from 10 cm³ to 5 dm³. The wall of the uterus has a thick muscular layer (myometrium) lined with a mucus membrane (endometrium). The uterus narrows at its bottom, the **cervix** (also known as the neck of the uterus, where it is connected to the vagina).

Vagina: This is an elastic, muscular canal with a soft, flexible lining that provides lubrication and sensation. The vagina connects the uterus to the outside world. The vagina receives the penis during intercourse, and also serves as a conduit for menstrual flow from the uterus. During childbirth, the baby passes through the vagina (birth canal).

Vulva: This is the external female sex organ, made of two lip-like folds of skin on each side of the vaginal opening: First the labia minora and then the labia majora. In between them is the clitoris, a sensitive organ with erectile tissue similar to that of the penis.

Gametogenesis

Gametes are formed through a process called gametogenesis. This takes place in the gonads (testicles and ovaries). Gametes are formed by germ cells which, like all other human cells, have 46 chromosomes. During gametogenesis, the **number of chromosomes is halved**, through a special type of cell division called **meiosis**. Therefore, each **gamete only has 23 chromosomes**, instead of 46. When an egg and a sperm join together during fertilization to form a zygote, the total number of 46 chromosomes is restored. The new cell contains a set of genetic material from the mother and a set from the father.

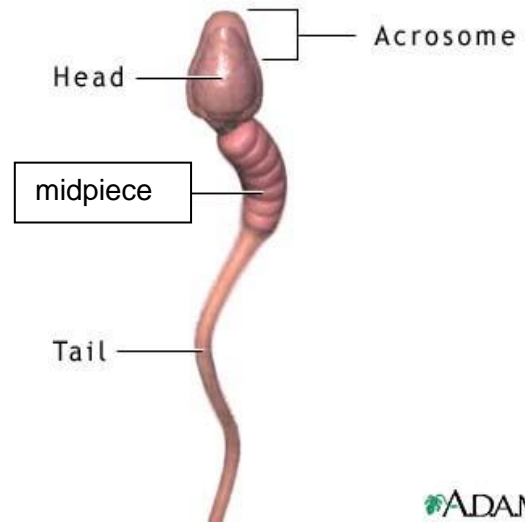
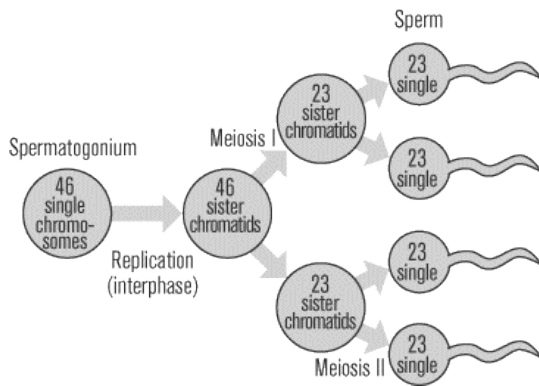
Spermatogenesis

Spermatogenesis or sperm production takes place in the walls of the seminiferous tubules of the testicles, from cells called **spermatogonia**. There are three stages to sperm production:

- **Growth:** The initial cells form, and then grow in size and number
- **Meiosis:** The most important stage. **The number of chromosomes is halved** from 46 to 23.
- **Maturation:** The cells produced during meiosis differentiate into sperm. They undergo the following changes: they grow longer, their cell volume is reduced, the front of the sperm (the head) develops a nucleus and the **acrosome**, which secretes enzymes in order to penetrate a protective layer the ovum has.

The formation and maturation of sperm is triggered by follicle stimulating hormone (FSH), released from the pituitary gland. The testes produce sperm continually at a rate of about 100 000 000 per day from puberty to old age.

There are around 120 million sperm in every milliliter of semen.



Sperm

Sperm are highly specialised cells that carry the genetic material of the male.

A sperm cell has three main parts: the head, the midpiece and the tail. In the head of the sperm is the nucleus which contains chromosomes (the genetic information from the father). The midpiece contains many mitochondria which provide energy to the tail, which makes the movement possible driving the sperm forward and allowing it to swim towards the egg.

The sperm determines the sex of the future child.

Oogenesis and the Menstrual Cycle

Oogenesis or production of mature eggs is a cyclic process, which includes the **ovarian and uterine cycles**. Both cycles are controlled and triggered by a series of hormones. Oogenesis begins very early in the life of a human female, when she's still a developing fetus. In fact, a human female is born with all the eggs she'll ever have.

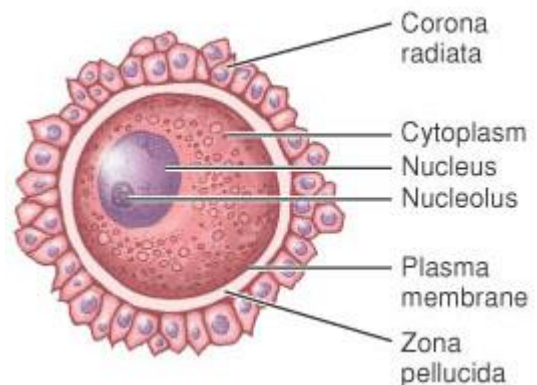
However, the eggs aren't quite finished, because cell division pauses early in the first half of meiosis. These eggs lie dormant from birth until puberty, at which time the monthly cycle of a woman's hormones restarts the development of eggs — usually one per month during her reproductive life, from puberty to middle age (menopause). The two ovaries take it in turns to produce a mature ovum, and one ovary releases a mature female gamete every 28 - 35 days. During the cycle a series of hormones will:

- prepare the uterus to receive any fertilised ova
- control the development of mature ova

Ova

Eggs or female sex cells are large round cells that, like sperm, also have 23 chromosomes. It does not move on its own, and it contains food reserve in the form of yolk to feed the zygote for the first few days after fertilisation.

The egg is covered by a complex protective layer, the *zona pellucida* and the *corona radiata*, which the sperm will have to cross in order to fertilise it.

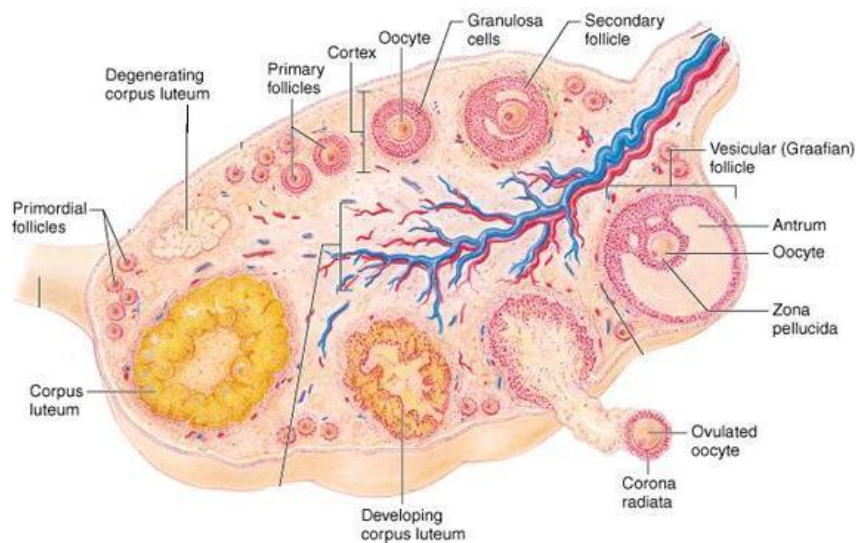


The ovarian cycle – hormones control the development of ova

Follicular phase (lasts around 14 days): The ova develop from cells lining the ovary. This is triggered by **follicle stimulating hormone (FSH)** released from the pituitary gland (in the brain). FSH stimulates the development of several follicles in the ovary at a time, but usually only one egg reaches full maturity. As the follicle matures it will produce a sac around itself. The developing ovum within the sac is called a **Graafian follicle**.

Ovulation (which means the release of a mature egg from the ovary's surface): Once the **Graafian follicle is matured**, and there is a **high concentration of oestrogen**, it moves to the surface of the ovary and bursts, releasing the ovum into the funnel of the oviduct. The release of the egg is stimulated by the **luteinising hormone (LH)** released by the pituitary gland. During this phase body temperature increases about 0.5 °C

Luteal phase: **LH** will also stimulate the development of **corpus luteum** from the remains of the follicle, which produces the hormone **progesterone**. Progesterone keeps the lining of the uterus ready for implantation and pregnancy. It also prevents FSH secretion which prevents the release of any more mature ova by feedback inhibition. (This ensures that only one fertilised ovum develops in the uterus at any one time). If there is no implantation, after 10-12 days the corpus luteum decays stopping production of progesterone and initiating a new cycle.



The menstrual cycle - Hormones affect the wall of the uterus

During the menstrual cycle, the wall of the uterus goes through **four phases** under the influence of two hormones, **oestrogen and progesterone**. During the **first phase**, which lasts about five days, the lining of the uterus is shed, accompanied by a loss of blood. This time is a woman's period or more correctly the **menstrual phase** or menstruation. The other phases of the cycle prepare the uterus to receive and protect a zygote:

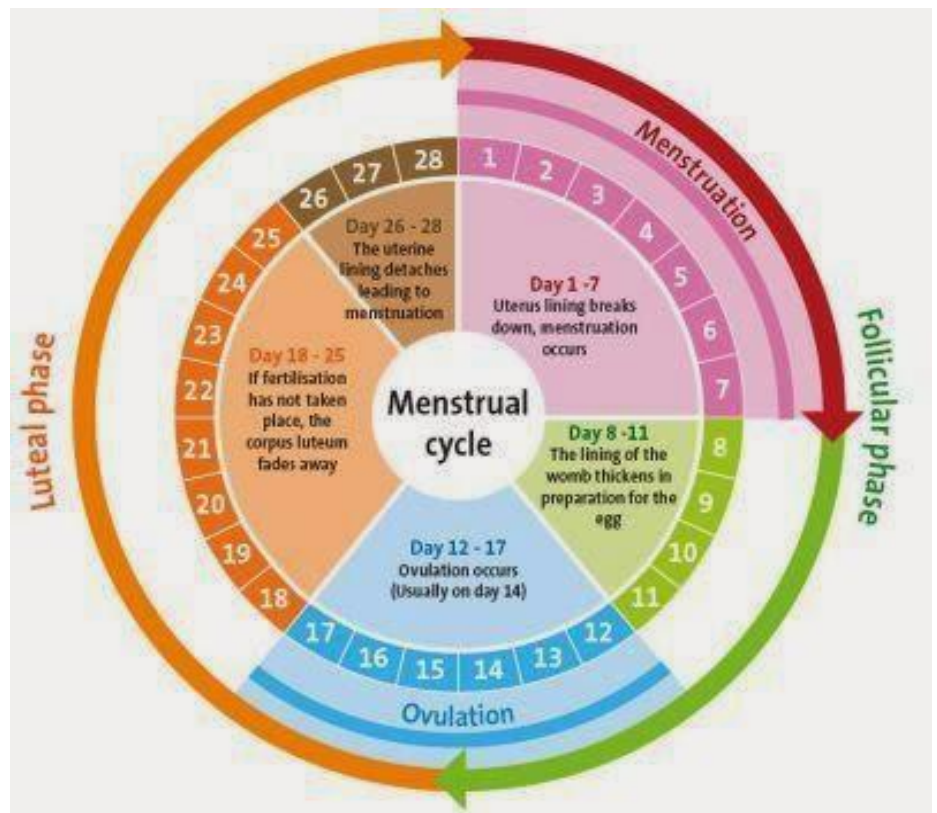
Menstruation: The uterus lining is shed. Blood and fragments of tissue leave the body through the vagina. Menstruation is triggered by a **decrease** in the concentration of **progesterone**. This phase lasts from 3 - 7 days.

Repair phase: More blood vessels grow in the lining of the uterus, and the lining thickens and becomes more stable. These changes are triggered by an increase in the concentration of oestrogen, produced by the ovaries. This phase lasts about 10-11 days.

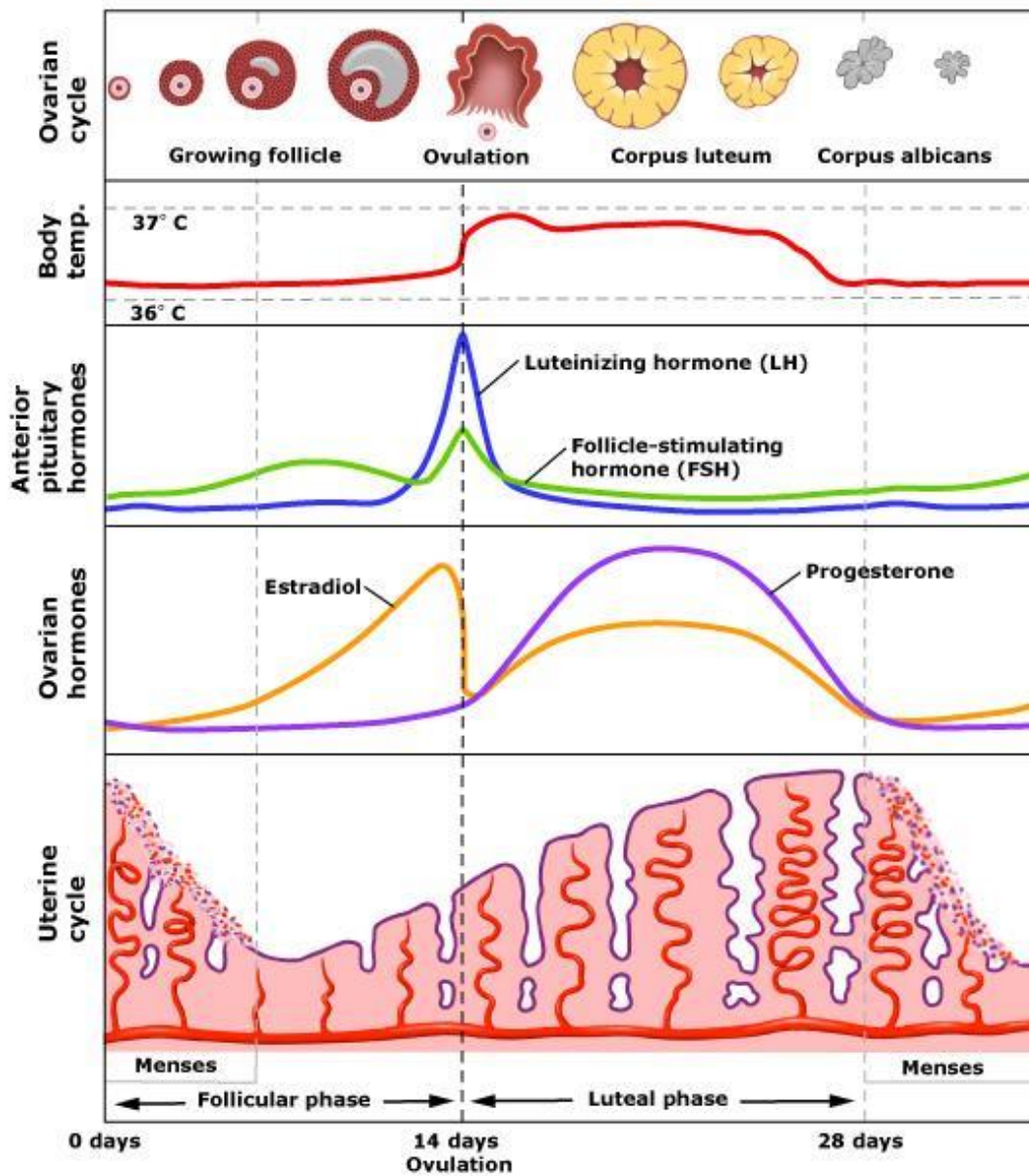
Following the development of a Graafian follicle (see ovarian cycle) an egg is released into the oviduct. Ovulation occurs at the peak of oestrogen concentration and is triggered by a hormone from the pituitary gland. (The release of the ovum is accompanied by a slight increase in temperature. Some women are actually aware of the moment of ovulation).

Receptive phase: The lining of the uterus and its blood vessels are now well developed. If fertilisation has occurred the embryo can become implanted. This optimum set of conditions for implantation remains from 6-7 days after ovulation, and is maintained by an increasing concentration of progesterone (released by the corpus luteum; see ovarian cycle).

Premenstrual phase: The uterus lining degenerates as the progesterone concentration starts to fall unless embryo implantation has occurred, in which case progesterone (from the corpus luteum) keeps the lining intact to begin pregnancy. This is the last few days before **menstruation**.



Understand this graph which explains the entire cycle (estradiol is an oestrogen)

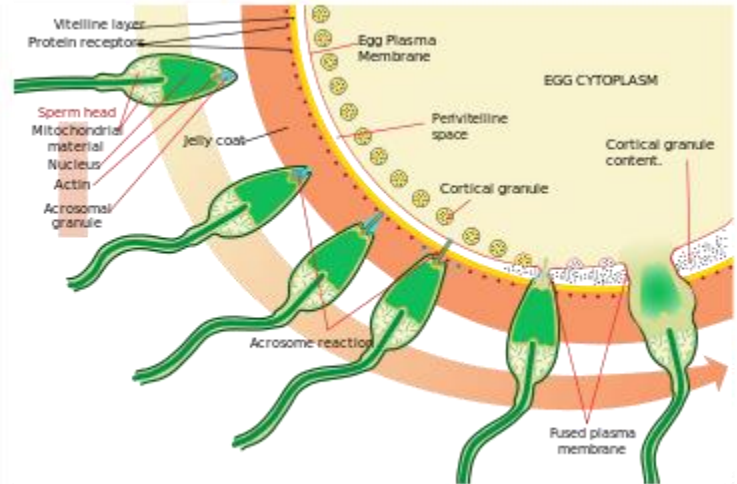


Fertilisation

During ejaculation about 300 000 000 sperm cells are released. They are up to 1000 times smaller than egg cells.

Though a very small amount of sperm make it to the site of fertilisation. Only one sperm cell can fertilise an ovum. Fertilisation occurs in the first third of the fallopian tube. After fertilisation the nuclei of the sperm (23 chromosomes) and egg cell (23 chromosomes) fuse to form a **zygote** restoring the total number of chromosomes humans have (46 chromosomes). The zygote starts to divide right away and will hopefully nestle itself in the endometrium when it reaches the uterus (**implantation**).

Watch this animation to understand it better ([LINK](#))



Sexuality

Sexuality is an important part of human life: it is not only related to reproduction, but also to feelings essential for each person's psychological development. It has both a biological and a social aspect.

Infertility, assisted reproduction and contraception

Infertility refers to the inability to have children using natural methods. It can occur in both men and women, and there are many different causes:

<i>Male infertility</i>	<i>Female infertility</i>
Low sperm count	No ovulation or problems with ovulation
Defective sperm	Fallopian tube obstruction
Sperm incompatible with cervical mucus	Uterine abnormalities which make it difficult for the embryo to implant

Nowadays, there are many assisted reproduction techniques used to help people who have infertility problems to have children.

Contraceptive methods can be used to avoid getting pregnant during sexual intercourse. There are natural and artificial methods of contraception.

Natural methods take into account the cyclical character of female fertility, and require that the couple adapt their sexual activity to the woman's menstrual cycle. These methods are a lot less reliable than other types of contraception.

Artificial methods are used to prevent fertilisation at any time. They do not involve adapting sexual activity to the menstrual cycle.

Natural methods of contraception

- **Rhythm method:** couples who use this method avoid having sexual intercourse during the fertile days of the woman's period.
- **Basal body temperature:** the woman measures her body temperature and looks for changes at ovulation.
- **Billings:** the woman notes changes that take place in the mucus of the vagina and cervix at ovulation.
- **Sympto- thermal:** a combination of the above three methods.
- **Withdrawal or *Coitus interruptus*:** the penis is withdrawn from the vagina before ejaculation. Of the natural methods this is **probably the most unreliable**, as small amounts of semen can leak out before the ejaculation.

Artificial methods of contraception

- **Barrier methods:** these methods physically prevent sperm from reaching the egg. They include male condoms, female condoms, diaphragms and IUD (intrauterine devices)

The **male condom** not only prevents sperm being released into the vagina, but it **also protects against sexually transmitted diseases** by reducing the risk of catching or spreading STDs.

A diaphragm or cup is a thin rubber with a springy outer ring to ensure a close fit. It prevents sperm from entering the uterus. It is often used with a spermicide cream.

IUD (intrauterine device) can be with or without hormones. It is a plastic-coated copper coil which may be left in the uterus for months or even for years.

- **Chemical methods:** These are chemical barriers and include spermicide creams, hormonal contraceptive (such as the pill), the morning-after pill and the 5-day morning-after pill.
The contraceptive pill is almost 100% reliable if taken properly. There are different kinds according to the hormones contained.
The morning-after pill is taken 48-72 hours after intercourse. It is not for regular use, but a doctor may prescribe it if there is a risk of unwanted pregnancy which might lead to an abortion at a later date. This pill contains hormones which cause the lining of the uterus to be shed. The 5-day morning-after pill is similar to the morning-after but need to be taken 120h after sexual intercourse.
Fitting an IUD within 72-96 hours of intercourse usually prevents pregnancy as well.
- **Surgical methods:** there are two surgeries that are used to permanently prevent fertilisation: tubal ligation for women, and vasectomy for men.
In female sterilisation, the oviducts are tied and cut during an operation. Released ova cannot reach the part of the oviduct where the sperm are present. It is not reversible, and should be considered by women who are sure that they do not want to have more children.
In a vasectomy the two sperm ducts are cut and tied in a surgical operation. Vasectomy, though complicated, can be reversed by an operation.

Remember that of all the above methods, **only the condom will protect you against sexually transmitted diseases (STDs), by reducing the risk of catching them.**

Sexually transmitted diseases (STDs)

Sexually transmitted diseases (STDs) are infections that you can get from having sex with someone who has the infection. The causes of STDs are bacteria, parasites and viruses. There are more than 20 types of STDs, including

- [Chlamydia](#)
- [Gonorrhea](#)
- [Genital herpes](#)
- [HIV/AIDS](#)
- [HPV](#)
- [Syphilis](#)
- [Trichomoniasis](#)

Most STDs affect both men and women, but in many cases the health problems they cause can be more severe for women. If a pregnant woman has an STD, it can cause serious health problems for the baby.

If you have an STD caused by bacteria or parasites, your health care provider can treat it with antibiotics or other medicines. **If you have an STD caused by a virus, there is no cure.** Sometimes medicines can keep the disease under control. However, some STDs can lead to death.

Correct usage of latex condoms greatly reduces, but does not completely eliminate, the risk of catching or spreading STDs.

References

- Anon, (2015). [online] Available at: <http://4.bp.blogspot.com/>- [Accessed 10 May 2015].
- Anon, (2015). [online] Available at:
<http://U1eDEukP0fA/VJkkldS8tjl/AAAAAAAAAV8/4swpyYXpoV8/s1600/menstrual%2Bcycle%2Bchart%2B-%2B3.jpeg> [Accessed 10 May 2015].
- Artificialinsemination.files.wordpress.com, (2015). [online] Available at:
<https://artificialinsemination.files.wordpress.com/2011/04/ovary-schematic.jpg> [Accessed 10 May 2015].
- Cabrera Calero, A. (2011). *Biology and geology, ESO 3*. [San Fernando de Henares]: Oxford Educación.
- Cycles, F. (2015). *Follow the Female Ovarian and Menstrual Cycles - For Dummies*. [online] Dummies.com. Available at: <http://www.dummies.com/how-to/content/follow-the-female-ovarian-and-menstrual-cycles.html> [Accessed 10 May 2015].
- Dynamisch.nu, (2015). [online] Available at:
<http://dynamisch.nu/feno/afbembryoengels/83ovary.jpg> [Accessed 10 May 2015].
- Healthline.com, (2015). *Bulbourethral Gland (Cowper's Gland) Anatomy, Function & Diagram | Body Maps*. [online] Available at: <http://www.healthline.com/human-body-maps/bulbourethral-cowpers-gland> [Accessed 10 May 2015].

Ibbio.pbworks.com, (2015). [online] Available at:

<http://ibbio.pbworks.com/f/1317538698/oocyte.jpg> [Accessed 10 May 2015].

Img.gawkerassets.com, (2015). [online] Available at:

<http://img.gawkerassets.com/img/19d5bsdvvfcvtpng/ku-xlarge.png> [Accessed 10 May 2015].

Nlm.nih.gov, (2015). *Sexually Transmitted Diseases: MedlinePlus*. [online] Available at:

<http://www.nlm.nih.gov/medlineplus/sexuallytransmitteddiseases.html> [Accessed 10 May 2015].

Passmyexams.co.uk, (2015). *Components of Blood, Cardiovascular System - Pass My Exams: Easy exam revision notes for GCSE Biology*. [online] Available at:

<http://www.passmyexams.co.uk/GCSE/biology/cardiovascular-system.html#1> [Accessed 4 May 2015].

Passmyexams.co.uk, (2015). *The Menstrual Cycle - Pass My Exams: Easy exam revision notes for GCSE Biology*. [online] Available at:

<http://www.passmyexams.co.uk/GCSE/biology/menstrual-cycle-and-hormones.html> [Accessed 10 May 2015].

Pearltrees.com, (2015). [online] Available at: <http://www.pearltrees.com/s/pic/or/veins-arteries-capillaries-56549509> [Accessed 4 May 2015].

Pickering, W. (2006). *Complete biology for IGCSE*. Oxford [England]: Oxford University Press.

Tpsbiology11student2.wikispaces.com, (2015). [online] Available at:

<http://tpsbiology11student2.wikispaces.com/file/view/bloodcomponents.jpg/186793981/bloodcomponents.jpg> [Accessed 4 May 2015].

Urgo.co.uk, (2015). [online] Available at: <http://www.urgo.co.uk/uploaded-files/img/images/venous-system-big-01.jpg> [Accessed 4 May 2015].

Webmd.com, (2015). *The Vagina (Human Anatomy): Picture, Parts, Function, Definition, and Problems*. [online] Available at: <http://www.webmd.com/women/picture-of-the-vagina> [Accessed 10 May 2015].

