

## Reproductive system

---

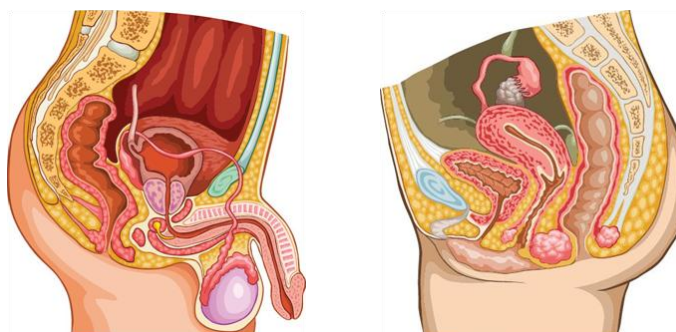
### Components

The primary reproductive organs, or gonads, are the testes in the male and the ovaries in the female.

These form part of a reproductive tract, a series of ducts in which gametes are produced, stored and transported:

- Male: epididymis, vas deferens (sperm duct), urethra which passes through the penis
- Female: Fallopian tube (oviduct), uterus, vagina

There are also accessory glands which supply secretions to the passageways, including (in the male) seminal vesicles and the prostate gland. In the female the breasts are also considered to be accessory glands.



**Figure 1** Unlike other body systems, which are more or less identical across genders, male and female reproductive systems are very different as they perform contrasting, though complementary, roles in the reproductive process.

### Functions

The male and female reproductive systems are designed for gametogenesis: the gonads produce male gametes (sperm) and female gametes (egg cells or ova), respectively. The penis of the male delivers sperm to the vagina of the female to enable the fusion of male and female gametes. The vagina also serves as a birth canal. In addition, the female system retains and nourishes the developing offspring in the uterus until birth when they can survive independently in the external environment. During early independent development, the breasts supply milk which contains not only nutrients, but antibodies.

Gonads also act as endocrine organs, secreting testosterone in males and oestrogen and progesterone in females.

The ability to reproduce and to perpetuate the species depends on a complex relationship between the reproductive organs and the hypothalamus, anterior pituitary, and the target cells of the sex hormones.

### Key mechanisms

#### Meiosis and fertilisation

Fusion of gametes (fertilisation) doubles the chromosome number at each generation. Meiosis (reduction division) halves the chromosome numbers of cells used to form gametes.

- Supplies of new cells are generated in the testes and ovaries by normal cell division (mitosis). These are diploid – they contain 23 *pairs* of chromosomes – one of each kind from the original mother and father.
- DNA in the chromosomes is replicated to give x-shaped chromosomes. Each side is a chromatid with identical DNA, joined at a centromere.
- Equivalent chromosomes from each parent pair off (they have DNA for the same genes) and separate, and the cell divides – this gives 23 chromosomes, one of each kind in the two daughter cells.

- Chromatids exchange portions during separation and any one from a pair can go with any one from another pair, so mother's and father's gene codes are mixed.
- Each gamete eventually produced will have a complete set of genes but a mixture of DNA codes taken from mother and father, giving a huge number of different combinations.
- The chromosomes split at the centromeres. The chromatids are pulled apart and the cell divides to form two new sets of 23 chromosomes formed from single chromatids.
- Four small cells which can develop into sperm are formed, but unequal division gives only one large cell from which an egg cell can form.
- Fertilisation fuses two haploid gametes (single sets of chromosomes) to give a diploid cell with 46 chromosomes, two of each kind, one from each parent.

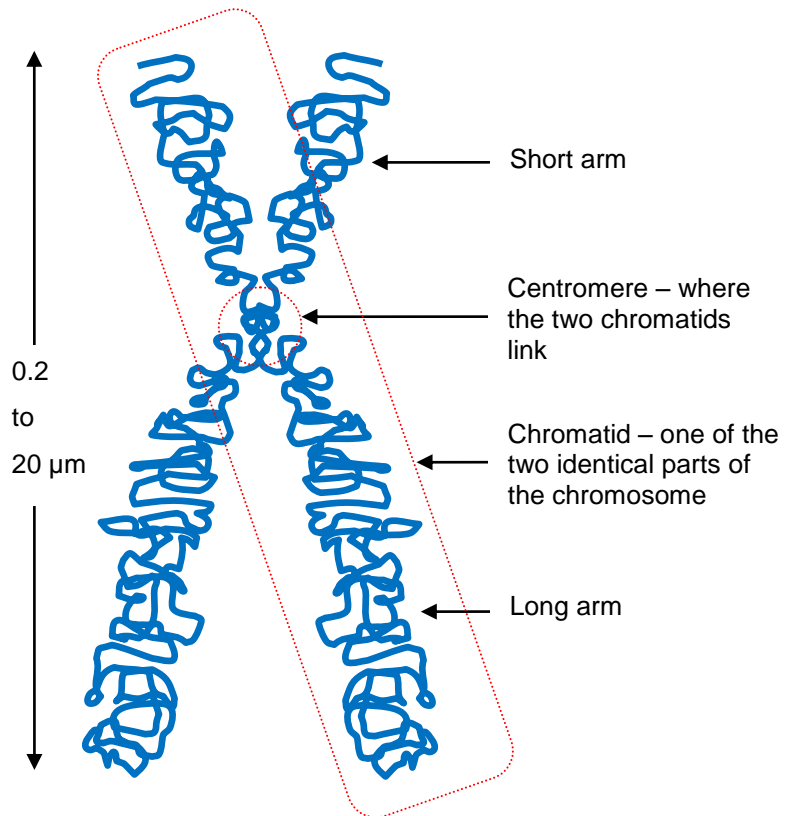


Figure 2 Representation of a chromosome.

### Sex determination

One of the 23 pairs of chromosomes is the sex chromosomes. Females have two X chromosomes, so egg cells normally contain one X-chromosome. Males have an X and a Y chromosome, so sperm can have either. Fertilisation by an X-carrying sperm gives a female, by a Y-carrying sperm gives a male.

### Erection of the penis

Sexual intercourse and transfer of sperm to the female reproductive tract through ejaculation relies on the ability of the penis to become erect.

Parasympathetic stimulation releases nitric oxide in the corpus cavernosum (spongy tissue) of the penis, which activates membrane guanylate cyclase receptors in smooth muscle in arteriolar walls. Release of cGMP (cyclic guanosine monophosphate) is triggered (acts as a second messenger). Muscle tissue in arterioles relaxes and they expand (vasodilation). Blood flow into the spongy tissue increases causing the penis to become erect. cGMP is broken down by phosphodiesterase.

### Role in homeostasis

The reproductive system does not contribute to the maintenance of a constant internal environment, essential for the survival of cells. However, it is essential for the survival of the species.

By ensuring genetic variation in offspring, sexual reproduction creates a gene pool for each species. The frequency of favourable genes will increase and unfavourable genes will decrease from generation to generation due to natural selection – the better adapted individuals will survive longer, have more offspring and pass on more of their genes into the gene pool. The ability of

humans as mammals and as chemical systems to efficiently maintain a constant internal environment independent from the external environment has come about through the evolution of many sophisticated homeostatic mechanisms over the millions of years since life arose on Earth.

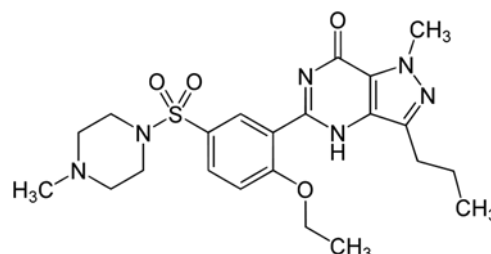
## Examples of what can go wrong

### Erectile dysfunction

There are a variety of causes of erectile dysfunction, which is the inability to sustain an erection to complete sexual intercourse. These include depression, the use of antidepressant drugs, or diabetes.

Sildenafil citrate, sold under various names including Viagra, has become standard treatment for the treatment of erectile dysfunction. It helps to increase and maintain erections.

- The action of cGMP specific phosphodiesterase is inhibited.
- cGMP is protected from degradation.
- Increased levels of cGMP enhance smooth muscle relaxation, increasing vasodilation and blood flow into the spongy tissue and maintaining blood flow for longer.



**Figure 3** Sildenafil. The citrate salt is sold under the brand name Viagra.

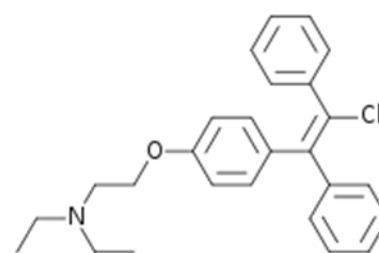
### Infertility treatment: Clomifene

Clomifene is used mainly to stimulate ovulation in women who have difficulty producing egg cells. Sometimes, it is used to obtain multiple ova for an *in vitro* fertilisation programme.

Clomifene is a selective oestrogen receptor molecule inhibitor. It increases the production of gonadotrophins, by inhibiting the effect of negative feedback on the hypothalamus.

At the beginning of the cycle follicle stimulating hormone (FSH) is rising and stimulating the development of follicles in the ovary. The follicles produce oestrogen which exerts negative feedback, inhibiting gonadotrophin releasing hormone (GnRH) and reducing FSH levels.

Clomifene given early in the cycle inhibits effect of oestrogen, so GnRH continues to stimulate FSH secretion and the growth of follicles leading to ovulation.



**Figure 4** Clomifene is used to treat infertility.

## Finding out

The molecular structure of sildenafil is similar to the cGMP specific phosphodiesterase type 5 (PDE5) and acts as a highly selective inhibitor by binding competitively with the enzyme. The drug therefore has few side effects.

Other medicinal drugs that act in the same way include tadalafil (Cialis) and vardenafil (Levitra).

Find the molecular structures of tadalafil and vardenafil and compare them with that of sildenafil.