Introduction

About one in six couples experience difficulty in achieving conception at some stage during their reproductive years. For some, this is temporary and pregnancy ensues spontaneously after a variable period of trying. However, there are others who can only become pregnant through medical intervention. Infertility is common, and most people will not find it hard to remember friends, relatives and/or other acquaintances with such problems. Not only is infertility common but the list of possible causes is quite extensive and to many this may initially appear intimidating. However, for conception to be possible, adequate numbers of good quality spermatozoa must be produced in the testes and delivered to the vagina at the right time in a woman's menstrual (ovarian) cycle. Conditions must be favourable for enough of these spermatozoa to ascend the female genital tract and arrive at the site of fertilization in the fallopian tube. They should be functionally adequate for the task of breaking through the cells that surround the oocyte to enable one of them to fertilize the oocyte. The fertilized egg should develop normally and implant successfully when it arrives at the uterine cavity as an embryo. Difficulty with conception will be experienced if any factor prevents the successful completion of these events.

It is estimated that 80 out of 100 couples are able to achieve pregnancy within one year of having regular sexual intercourse without contraceptives. Ten more couples will get pregnant in the second year while the remaining 10 couples are not able to do so within that time frame and are said to be infertile. However, some of these infertile couples may still achieve pregnancies without any assistance in the third or subsequent years of trying. Since it took them all this time to get pregnant they are said to be subfertile; their fertility is impaired to some extent but not completely. The remaining couples (usually 3–5%) rarely achieve conception unless some form of treatment is provided. This is because one or both members of the couple could be sterile. Infertility therefore encompasses subfertility and sterility. Infertility is defined as an inability to achieve pregnancy within two years of having regular unprotected intercourse. Some authorities may use one year as the cut-off point. Infertility is a problem of the couple. None of the partners can be said to be infertile; one or both partners may be subfertile or sterile. There are about 60–80 million infertile couples world-wide. Infertility is said to be primary if the couple have had no previous pregnancy and secondary if there has been at least one pregnancy irrespective of its outcome (miscarriage, ectopic pregnancy and preterm or term delivery). The male partner is solely responsible in 40% of infertility cases while the female partner is responsible for another 40%. Both are responsible for the remaining 20% of cases.

Steady progress has been made in recent decades in the treatment of infertility. Consequently, a large proportion of infertile couples should now have a realistic expectation of being able to have children, although it may take time and many treatment attempts for this to happen. Treatment could be by the administration of medication or performing surgery or a combination of both. Couples in whom these treatments are unsuccessful or are not suitable can have assisted conception treatment; several thousand babies have now been delivered world-wide following the birth of the first so-called 'test-tube' baby in 1978. Infertility is associated with psychological upheaval and perpetual mental anguish. Furthermore, infertility treatments impose physical, social, financial and mental stress on the couple. The stress is worse with the assisted reproduction technologies and success is not guaranteed in the first or any specific cycle of treatment. Knowledge and information are the best tools with which infertile couples can tackle their problem and obtain the best possible treatment for themselves. They need to know about their bodies and how conception takes place. They also need to know when, how and where to seek assistance for their continued inability to conceive. They should be aware of the various available treatment modalities, their efficacy and drawbacks. Their knowledge of the subject matter should be enough to allow them to follow their treatment as it progresses thereby making for better compliance with the treatment regimens. A book such as this fulfils these objectives. In addition, it ensures that the busy practitioner and the non-medical members of the team have access to a simple yet comprehensive text, that will enable them to optimally perform their various roles in the care of infertile patients.

1

The male reproductive system

Introduction

The anatomy and function of the male genital organs fulfil certain roles during the reproductive process; copies of the man's genetic make up are packaged in spermatozoa which are produced in the testes. These gametes are then conducted along the male genital tract. Ejaculation results in their deposition in the vagina if intravaginal intercourse takes place. A simplified physiological anatomy of the male genital tract will be presented in this chapter.

The male sex organs

The male sex organs consist of the testes, excretory ducts, accessory glands and the penis (Table 1.1 and Figure 1.1). The testes (singular: testis) are two oval structures that normally lie in the scrotum (Figure 1.2). Each testis measures 4–6 cm in length and has a volume of about 25 ml. The testes produce spermatozoa (singular: spermatozoon) and testosterone (the male hormone). A mature spermatozoon is shown in Figure 1.3. It is a highly specialized cell that is designed for movement. The sole function of the spermatozoon is to carry a copy of the man's genetic make up, in the form of chromosomes, from the site of production in the testis, through the male and female genital tracts, to the egg that it fertilizes. The spermatozoon carries this genetic material in the head piece. The rest of the spermatozoon is made up of the mid-piece, which supplies the energy, and the tail which propels the sperm forward.

Production of spermatozoa commences at puberty and takes place inside highly coiled tubes that are found in the testes called seminiferous tubules (Figure 1.4). Following their production, spermatozoa are wafted along the seminiferous tubules, by a fluid current, and enter the excretory ducts. The epididymis is a highly coiled tube measuring 5–6 m if unwound fully. It connects the tubules of the testis to the vas deferens. The vas deferens is 35–45 cm long. From its point of origin in the scrotum the course of the vas deferens is upwards to the groin. It then enters

Table 1.1. The male reproductive organs

Components	Number
Testis	2
Excretory ducts	
epididymis	2
vas deferens	2
Accessory sex glands	
seminal vesicle	2
prostate	1
bulbo-urethral gland	2
Ejaculatory duct	2
Urethra	1
Penis	1

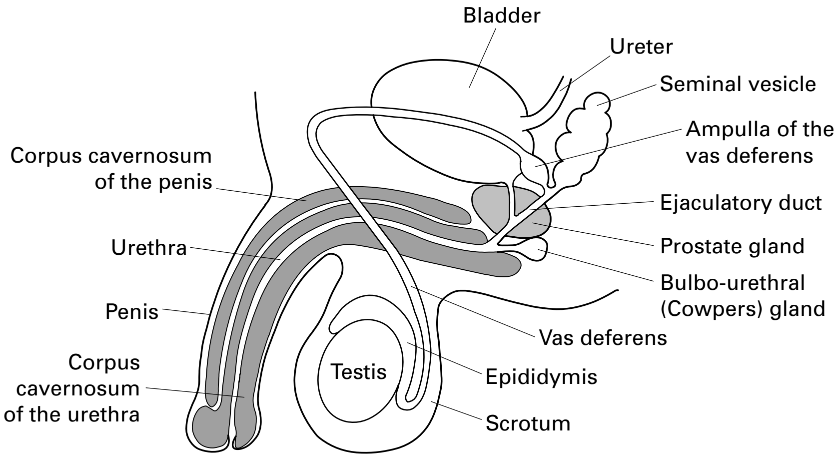

Figure 1.1 The male sex organs: side view.

the body cavity through a tunnel (called the inguinal canal) where it joins the duct of the seminal vesicle on that side to form the ejaculatory duct. Spermatozoa reaching the ejaculatory duct from the vas deferens of each side are ejected from the penis, which is the copulation organ, together with secretions from the accessory sex glands (seminal vesicles, prostate gland and bulbo-urethral glands) at the time of ejaculation. The urethra also conducts urine from the bladder to the exterior during urination. The prostate is the largest accessory sex gland. It weighs 20 g and is 3–4 cm in diameter.

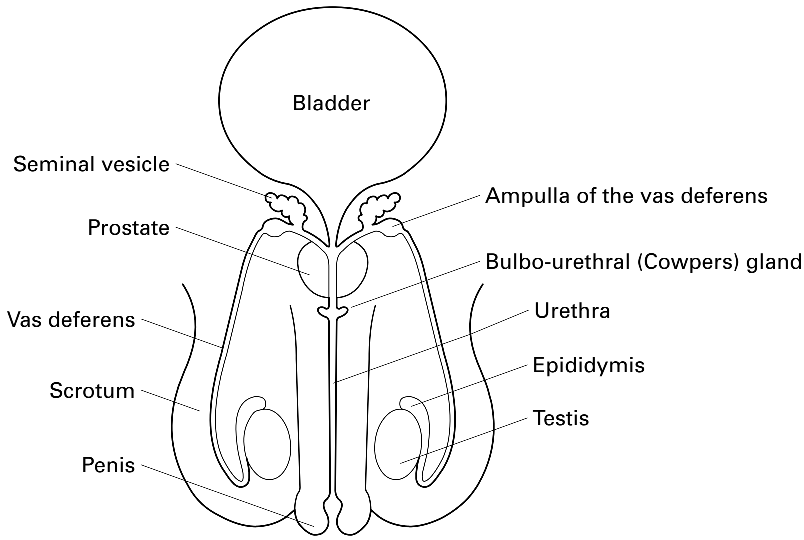

Figure 1.2 The male sex organs: front view showing paired components.

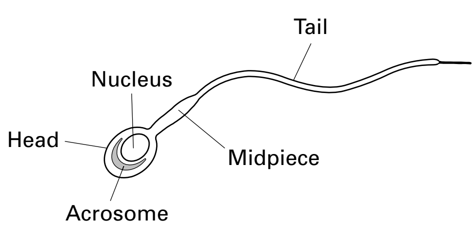

Figure 1.3 A mature spermatozoon.

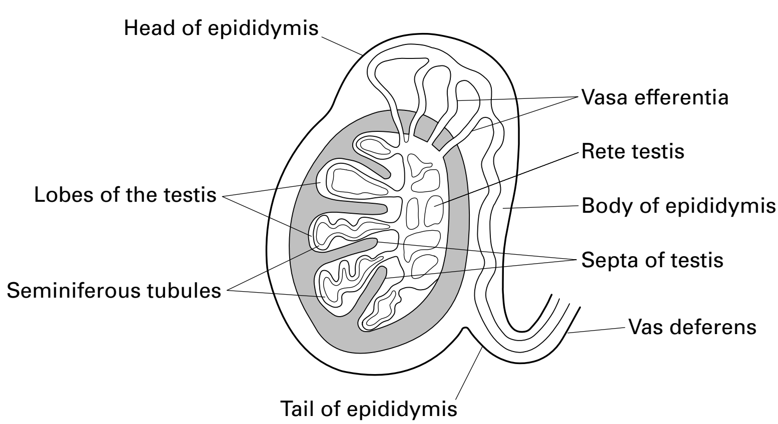

Figure 1.4 Section through the testis showing the organization of the various systems of tubules.

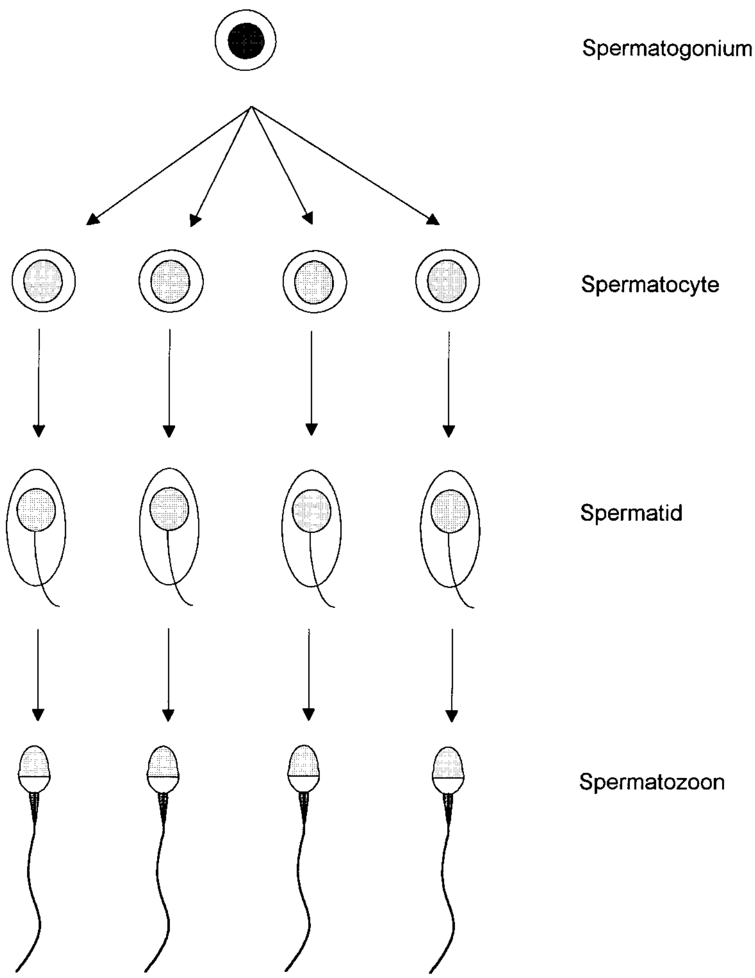

Figure 1.5 Major stages during production of spermatozoa in the testes.

Production of spermatozoa

The testes hang well out of the body cavity in the scrotum; this is necessary to keep the testes cooler than the rest of the body which is at 37 °C. The temperature of the testes while in the scrotum can be up to 4–7 °C lower than that of the body. The lower temperature is required for optimal production of spermatozoa. Spermatozoa develop from spermatogonia which are cells that line the inside of the seminiferous tubules. The spermatogonia do not just change into spermatozoa. They divide repeatedly and the resulting cells go through a complex series of changes before becoming fully formed spermatozoa (Figures 1.5 and 1.6). These processes take about 64 days to be complete in the testes. It then takes another

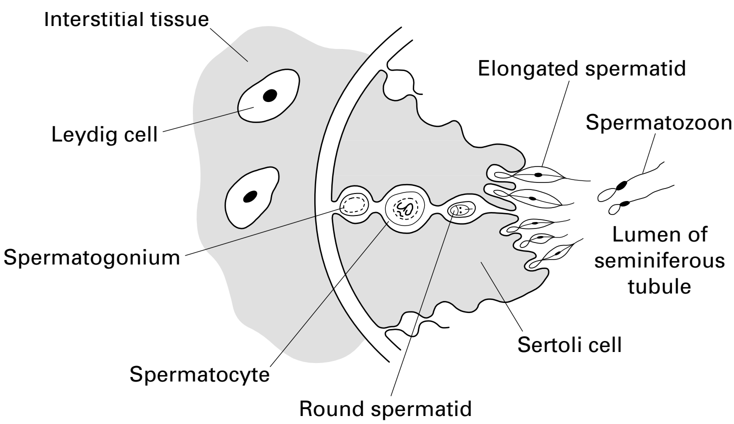

Figure 1.6 Transverse section through a seminiferous tubule and adjoining interstitial tissue.

10–14 days for these spermatozoa to pass through the epididymis and vas deferens. Although fully formed in the testes, spermatozoa are not completely mature and do not usually move. Their transit through the seminiferous tubules and into the epididymis is as a result of movement of the fluid in which they are suspended. The fluid current is set up by Sertoli cells which continuously secrete fluid into the seminiferous tubules. Sertoli cells are one of the groups of cells found within the seminiferous tubules. The spermatozoa may begin to move when they enter the epididymis but the movement tends to be in circles. Full motility is however achieved by the time they leave the epididymis. The epididymis acts as a storage organ for spermatozoa. The vas deferens also acts as a storage organ but the number of spermatozoa it contains at any point in time is usually just enough for one ejaculation. The transport of spermatozoa through the epididymis and vas deferens is by means of contraction of muscles found within the walls of these hollow tubular structures.

Development of the testis

The testes originally lie in the abdomen of the developing male fetus but descend into the scrotum during the later part of pregnancy. Cells that will eventually produce spermatozoa (called primordial germ cells) are deposited in the testes in the early stage of testicular development. These primordial germ cells arise in the yolk sac of the embryo and migrate, between the fourth and sixth week of pregnancy, to the genital ridge that eventually forms the testes. The primordial germ cells develop into spermatogonia and lie dormant until the boy reaches puberty when the spermatogonia resume cell division and further development. The testes

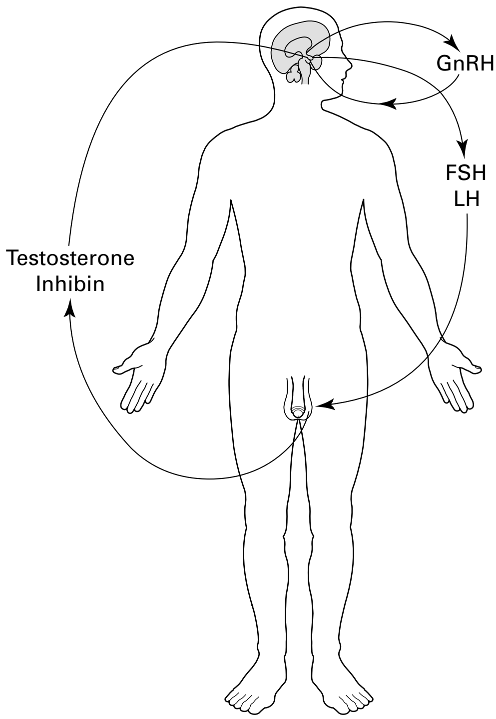

Figure 1.7 An adult male and the distance separating the hypothalamus and pituitary gland from the male sex organs.

do not become depleted of spermatogonia unlike the situation in the female, as will be seen in Chapter 2.

Hormones that control the function of the adult male sex organs

The hypothalamus and pituitary gland are located in the brain and influence the function of the male sex organs, although they themselves are not sex organs. Both glands secrete hormones (Figure 1.7). Gonadotrophin releasing hormone (GnRH) is one of the hormones secreted by the hypothalamus. GnRH enters blood vessels in the brain to reach the pituitary gland which it stimulates to produce two other hormones. One is the follicle stimulating hormone (FSH) while the other is the luteinizing hormone (LH). Both FSH and LH are secreted into the blood stream through which they reach the sex organs. Inhibin, another hormone, is produced by Sertoli cells, while testosterone is produced by cells that lie outside the seminiferous tubules – the Leydig cells. FSH stimulates the production of spermatozoa within the seminiferous tubules while LH stimulates Leydig cells to produce testosterone. FSH also contributes to the stimulation of Leydig cells to produce testosterone (Figure 1.8).

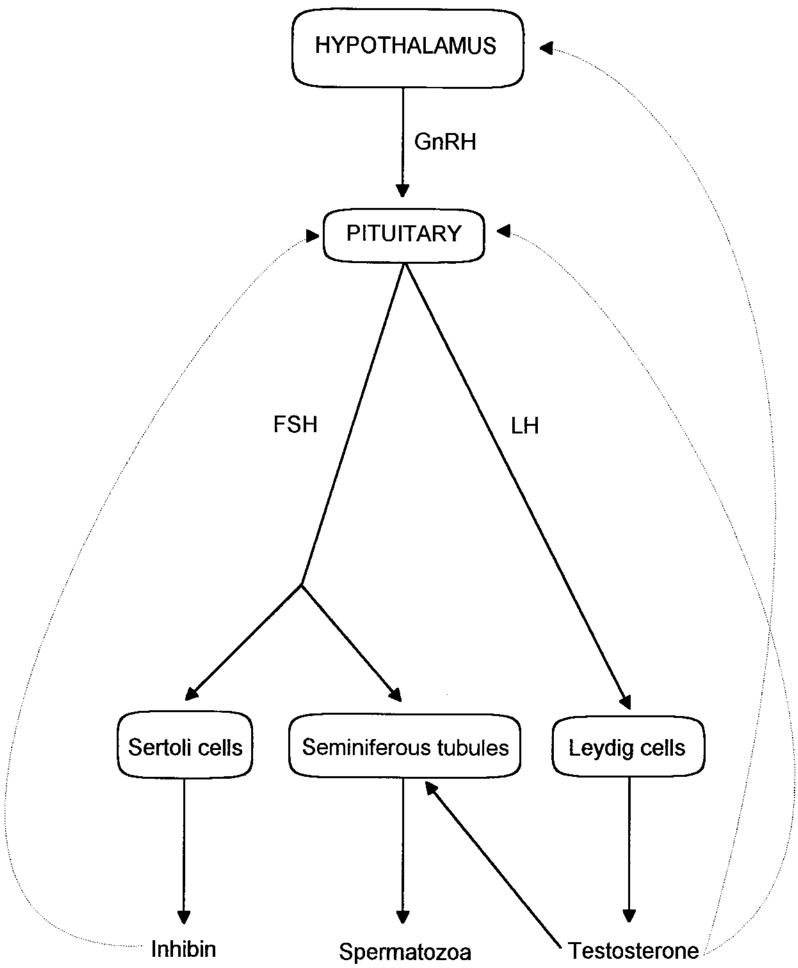

Figure 1.8 Hormonal control of testicular function.

In the adult, testosterone maintains the size and function of the various sex organs and is important for the production of spermatozoa. Feedback control mechanisms are present in various organs of the body and help to keep the production of compounds and materials at a constant level. In relation to the male reproductive organs, testosterone controls the production of LH; when the concentration of testosterone in blood decreases, the release of LH is increased and vice versa. Part of the feedback control of testosterone on LH production is through its effect on the production of GnRH by the hypothalamus. When the production of spermatozoa drops, the production of inhibin by the Sertoli cells also drops. The pituitary senses the low level of inhibin and increases the production of FSH. FSH then stimulates production of more inhibin and spermatozoa (Figure 1.8).

Table 1.2. Constituents of semen

Cells	Chemical compounds
Spermatozoa	Water
White blood cells	Hormones
Epithelial cells	Proteins
(Red blood cells)	Carbohydrates
(Bacteria)	Steroids
(Viruses)	Lipids
	Other compounds

Erection and ejaculation

Sexual arousal and excitement in men result from input of the various senses (sight, touch, sound, smell and taste). Erection of the penis is usually one of the earliest manifestations of sexual arousal. There is also erection of the nipples, increase in the heart rate and blood pressure. The excitement is maintained and even increased by sexual intercourse or masturbation. At the height of sexual excitement the smooth muscles in the walls of the epididymides and vasa deferentia (plural of vas deferens) contract and expel spermatozoa into the urethra. The muscles in and around the prostate and seminal vesicles also contract and these glands discharge their secretions into the urethra. This is also the time during which the man begins to orgasm; there is a release of sexual tension and arousal and the man has an intense feeling of pleasure. The muscles at the neck of the bladder contract and this prevents spermatozoa and the secretions from flowing back and into the bladder. Within a very short period after the emission of spermatozoa and the accessory sex gland secretions, there is repeated contraction of the muscles of the pelvis, lower extremities and the trunk. The smooth muscles of the urethra contract along with other muscles in the penis. This has the effect of expelling semen from the urethra to the outside which if the man is having vaginal sexual intercourse at that time, will be expelled into the vagina.

Composition of semen

Semen is the fluid that is ejected from the penis at the time of orgasm. It should not be confused with pre-ejaculatory fluid which is produced by the bulbo-urethral glands during sexual excitement and before ejaculation. Pre-ejaculatory fluid is thin and clear and serves to flush the urethra and neutralise any acidic remnants of urine. The constituents of semen are shown in Table 1.2. The volume of semen produced during ejaculation is usually between 2 and 6 ml. The seminal vesicles