Chapter 17

HUMAN REPRODUCTIVE SYSTEM

STUDENTS'LEARNING OUTCOMES

After studying this chapter, the students will be able to:

- Describe the structures of the male reproductive system and identify their functions.
- Define male reproductive hormones and explain their functions
- Explain the structures of female reproductive system and describe their functions
- Describe the menstrual cycle and the hormones involved.

You know that reproduction means the ability of an organism to produce new offspring of its own type. In this chapter, we will learn about the human reproductive system in more detail.

17.1- Reproductive Systems

The functions of reproductive systems include the production of reproductive cells (gametes) and the preparation of gametes for fertilization. In addition, the male reproductive system delivers the gametes to the female reproductive system and the female reproductive system nourishes the fertilized egg cell and provides an environment for its development into baby.

For Information

The human reproductive system is different from other organ systems in two aspects.

i. The reproductive system is quite different in male and female. While, the other organ systems are almost the same.

ii. The reproductive system does not become functional until at puberty. In contrast, all other body systems are functional since or shortly after birth.

17.1.1- Male Reproductive System

The components of the male reproductive system and their functions are described below.

1- Gonads (Testes)

Two testes are located outside the abdomen in a skin pouch called **scrotum**. Each testis is oval-shaped and measures about 3–5 cm in length and 2–3 cm in width. A testis is composed of highly convoluted **seminiferous tubules**. The wall of the seminiferous tubules i.e., **germinal epithelium** contains two types of cells i.e.,

germline cells and **Sertoli cells**. The germinal cells make sperms (spermatozoa) by meiosis. Sertoli cell nourish the developing sperms.

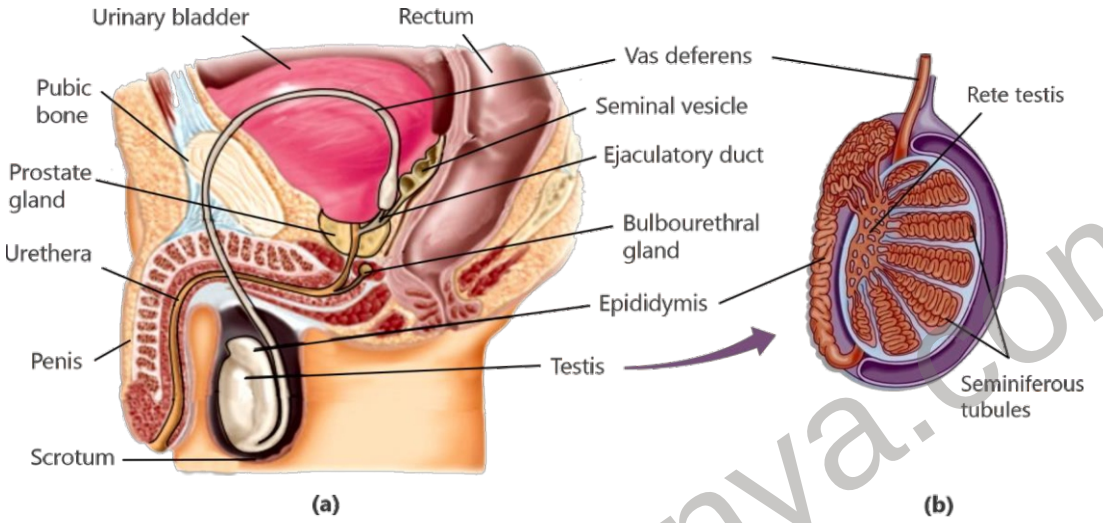

Figure 17.1: (a) Male reproductive system; (b) Cross section of a testis

2- Accessory Ducts

From seminiferous tubules, the spermatozoa enter into a network of tubules called **rete testis**. From here, they enter into a long, coiled tube called the **epididymis**. Here, the spermatozoa are still non-motile. They remain in epididymis for at least 18 hours. Then, they become motile and enter another long tube, the **vas deferens**. The vas deference passes into the abdominal cavity via the inguinal canal.

For Information

During development, the testes are formed within the abdominal cavity. Shortly before birth, they descend through an opening into the scrotum. The scrotum maintains the testes at around 34°C. This temperature is slightly lower than the core body temperature (37°C). This lower temperature is required for the development of sperms.

The vas deferens from each testis joins with a duct from a seminal vesicle (a gland). After joining, the tube is called the **ejaculatory duct**. The two ejaculatory ducts coming from two testes pass through a prostate gland. Here, they open into the urethra, which comes from the urinary bladder. The urethra opens out of the body through the penis.

3- Accessory Glands

These are the glands that add fluids to sperms to form semen.

i. There are two **seminal vesicles**. Each of these glands releases a fluid rich in fructose (sugar) into the vas deferens through a duct. This fluid provides energy for the sperm.
ii. The **prostate gland** lies just below the urinary bladder. It is soft and spongy and produces about 60% fluid of the semen. Semen is a mixture of sperms and fluids from the seminal vesicles and the prostate gland.
iii. There are two small **bulbourethral glands**. They secrete a clear fluid that lubricates the urethra for sperm passage and provides a protective neutral environment for sperms to survive.

4- Copulatory Organ (Penis)

The male copulatory organ is called penis. It contains urethra, erectile tissue, an artery and two veins.

Spermatogenesis (Production of Sperm)

Spermatogenesis is the process by which sperm are formed inside the seminiferous tubules of the testes.

In the walls of seminiferous tubules, special cells called germline cells (2n) divide by mitosis. Some of the new cells become **spermatogonia** (2n), while others remain as germline cells for future use. The spermatogonia continue to divide and form **primary spermatocytes** (2n). Primary spermatocytes move toward the inner space (lumen) of the tubules. Each primary spermatocyte divides by meiosis-I to form two **secondary spermatocytes** (1n). These cells quickly undergo meiosis-II to produce spermatids (1n). In this way, one spermatogonium (2n) produces four spermatids (1n). Each spermatid matures into an elongated sperm.

A sperm consists of three parts i.e., a head, a midpiece and a tail. The genetic material is present within its **head**. About two-thirds of the head is surrounded by a thick cap called the acrosome. The **acrosome** is formed mainly of Golgi Body. It contains enzymes that later help the sperm to fertilize the ovum. The **midpiece** contains mitochondria and a centriole. The **tail** is formed of microtubules (axial filament) which arise from the centriole of midpiece.

The mature spermatozoa present in the lumen of seminiferous tubules are non-motile. They enter the epididymis with the help of the fluid secreted by Sertoli cells. In the epididymis, they gain motility.

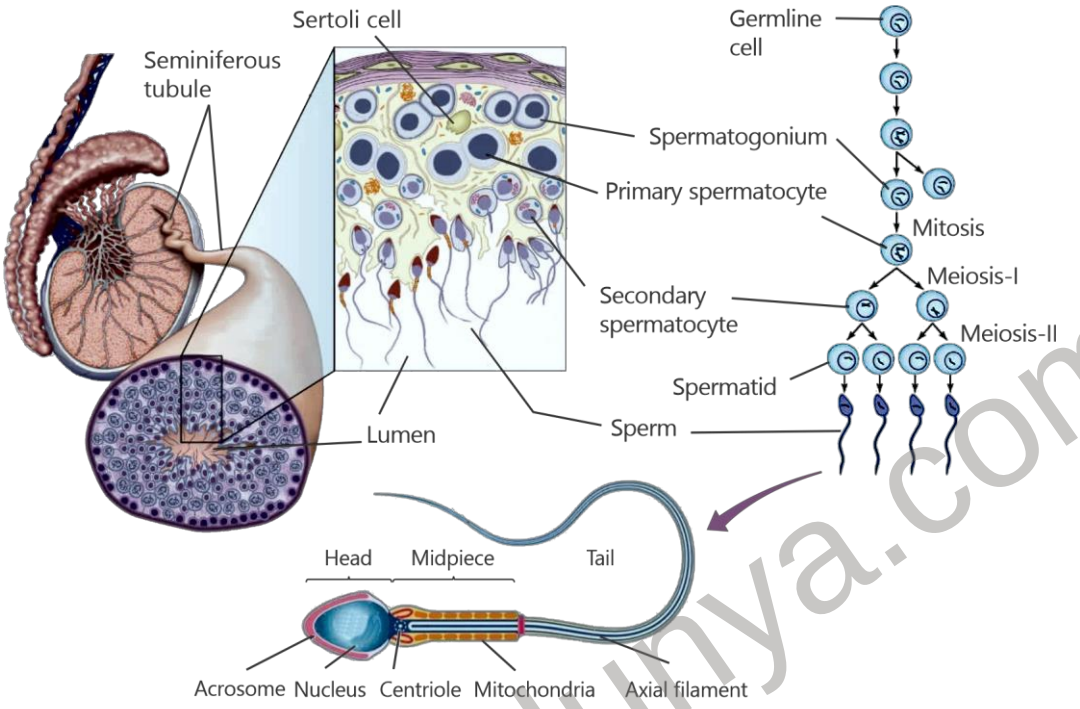

Figure 17.2: Spermatogenesis and structure of sperm

Hormonal Control of Male Reproductive System

Spermatogenesis is controlled by hormones of hypothalamus and pituitary gland. The hypothalamus releases gonadotropin-releasing hormone (GnRH). It stimulates the anterior pituitary to release follicle-stimulating hormone (FSH) and luteinizing hormone (LH).

FSH stimulates seminiferous tubules for spermatogenesis. LH stimulates **Leydig cells** (located in the interstitial tissue between the seminiferous tubules) to secrete **testosterone**.

Testosterone stimulates the development of germinal epithelium. It also maintains male secondary sexual characteristics. When FSH is released by the anterior pituitary, it causes the Sertoli cells to release a peptide hormone called

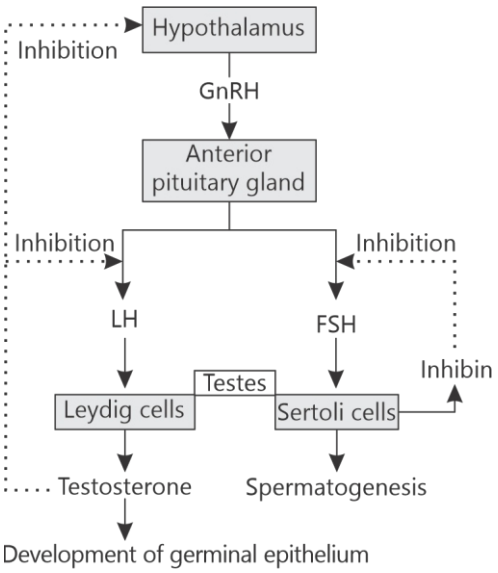

Figure 17.3: Hormonal control of male reproductive system

inhibin that inhibits further FSH secretion. Similarly, when LH stimulates Leydig cells to secrete testosterone, the release of testosterone inhibits the release of LH and GnRH.

17.1.2- Female Reproductive System

The female reproductive system consists of gonads, oviducts, uterus and vagina. The oviducts, uterus and vagina are called accessory organs of the female reproductive system.

1- Gonads (Ovaries)

Ovaries produce egg cells (ova or oocytes) and release hormones. There are two ovaries – each present on the side of the uterus. An oval-shaped ovary is 3-5 cm long and 2-3 cm wide. It contains many tiny sac-like structures called **ovarian follicles** which are the functional units of ovary. Follicles nurture immature eggs. In adult female, one of the ripening follicles ejects its egg cell each month. This event is called **ovulation**. After ovulation, the ruptured follicle is transformed into a glandular structure called the **corpus luteum**.

2- Oviducts (Fallopian tubes)

The oviducts (also called fallopian tubes or uterine tubes) are two tubes leading from the ovaries into the uterus. When an ovum matures, the ovarian follicle and ovary wall rupture to release it. The ovum enters an oviduct and travels toward the uterus. This movement is facilitated by the movements of cilia on the inner lining of oviduct. Fertilization of the ovum also occurs in oviduct. The resulting zygote undergoes several mitotic divisions while still in oviduct.

3- Uterus

The two oviducts enter into a hollow and muscular organ called uterus. It consists of three parts i.e., fundus, body and cervix. **Fundus** is the uppermost rounded portion above the openings of oviducts. The **body** of the uterus makes it major portion. The lower narrow part of uterus is called **cervix**. The opening of cervix leads to the vagina.

The wall of the uterus is composed of three layers. The **perimetrium** is the outermost thin layer. The **myometrium** is the middle thick layer composed of smooth muscles. The **endometrium** is the inner spongy lining. It has a basal layer and a functional layer. The **basal layer** has the stems cells which regenerate the functional layer. The **functional layer** thickens and is shed during the menstrual cycle. During pregnancy, it further thickens to implant the embryo. Its vascular spaces fuse and become interconnected, forming the **placenta**, which supplies oxygen and nutrition to the embryo and foetus.

4- Vagina

It is a thin-walled 8-10 cm long tube leading from the outside to the cervix of uterus. It provides a passageway for delivery of infant and for menstrual flow.

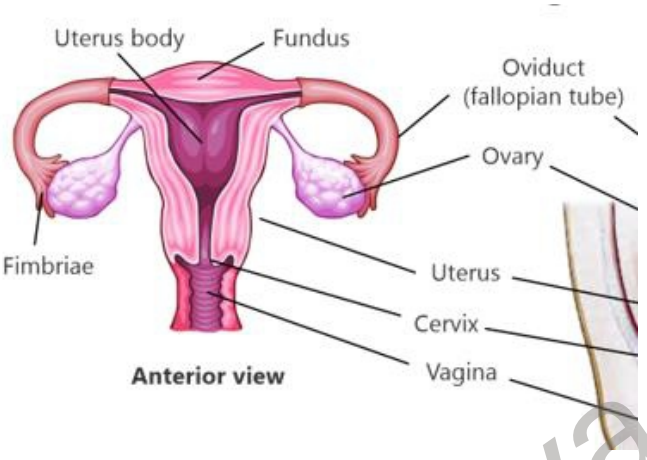

Figure 17.4: Human female reproductive system

Oogenesis (Production of Ovum)

The production of ovum starts during the embryonic development of female. In that period, the **oogonia** (2n) present in follicle divide by mitosis to produce **primary oocytes** (2n). These primary oocytes begin the first meiotic division, but stop in prophase-I. They remain in prophase-I all through childhood (for at least 10 to 14 years).

At puberty, only one of the many primary oocytes present in ovary resumes meiosis-I and produces two dissimilar haploid cells. The larger cell is the **secondary oocyte** (1n) while smaller one is called the **first polar body** (1n). The secondary oocyte stops division in metaphase-II. It released from the body. If an ovulated secondary oocyte is not fertilized by a sperm, it

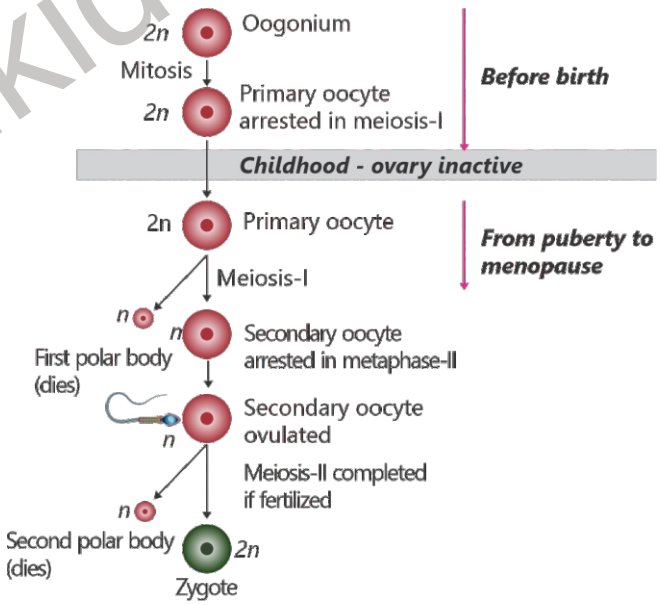

Figure 17.5: Oogenesis

dies. But, if a sperm fuses with the secondary oocyte, it quickly completes meiosis II (in oviduct). It produces two new cells i.e., one large **ovum** (1n) and a small **second polar body** (1n).

For Information
At birth, a female's ovaries contain some 2 million follicles, each with a primary oocyte.

17.1.3- Female Reproductive Cycle – The Menstrual Cycle

The female reproductive system functions by going through cyclic events, collectively called the menstrual cycle. The menstrual cycle lasts approximately one month (28 days on average). It can be divided into the following phases.

1. Menstrual Phase (Days 1-5)

In this phase, the functional layer of endometrium is shed. The detached tissue and blood move out of the body. This step is called **menstruation**. It continues for 3-5 days. It occurs due to low levels of estrogen and progesterone hormones. The gonadotropins and FSH begin to rise in this phase.

2. Proliferative Phase & Ovulation (Days 6-14)

Due to the rise in FSH, few ovarian follicles begin growing. But, only one follicle grows full and the others degenerate. This mature follicle is called **Graafian follicle** rises to the surface of the ovary.

FSH stimulates the Graafian follicle to secrete estrogen hormones. It causes the initial vascularization of endometrium and makes it velvety and thick again. As the concentration of estrogen rises, the level of FSH falls due to negative feedback. Due to the fall in FSH level, the anterior pituitary releases LH. It happens at the end of the proliferative stage (day 14). The sudden release of LH from the anterior pituitary stimulates Graafian follicle to release the ovum into the oviduct. This phase is known as **ovulation**.

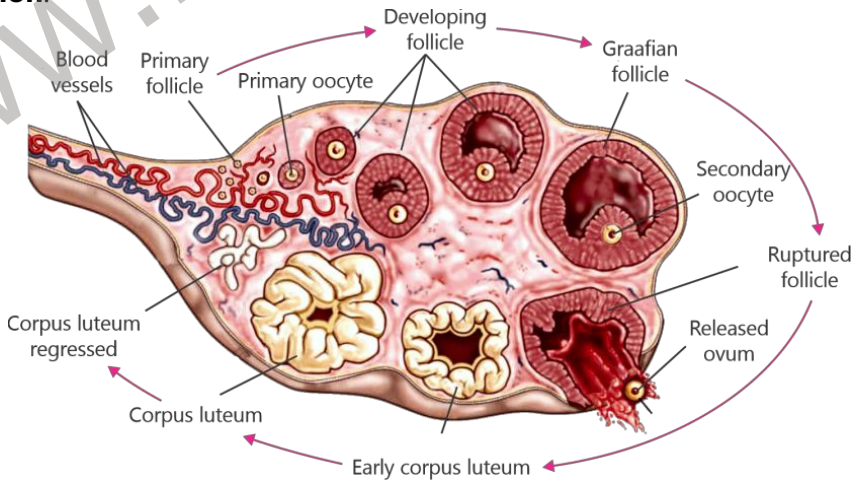

Figure 17.6: Changes in ovary during menstrual cycle

3. Secretory/Post-Ovulatory Phase (Days 15-28)

After ovulation, LH stimulates the ruptured Graafian follicle to develop into a yellow structure called the **corpus luteum**. Copus luteum secretes estrogen and progesterone hormones which make the endometrium more vascular and glandular.

If fertilization does not occur, the corpus luteum starts to degenerate. As a result, the anterior pituitary stops secreting LH. The destruction of corpus luteum also results in an abrupt fall in the concentration of estrogen and progesterone. It causes the thickened endometrium to be shed with bleeding i.e., menstruation on day 28.

For Information

In human females, menstrual cycle stops around 50 year of age and it is termed as menopause.

For Information

When the ovulated oocyte is fertilized, the tiny embryo secretes human chorionic gonadotropin (hCG). This hormone maintains the corpus luteum. So, the levels of estrogen and progesterone keep high and menstruation is prevented. Because hCG comes from the embryonic chorion and not the mother, it is the hormone that is tested for in all pregnancy tests.

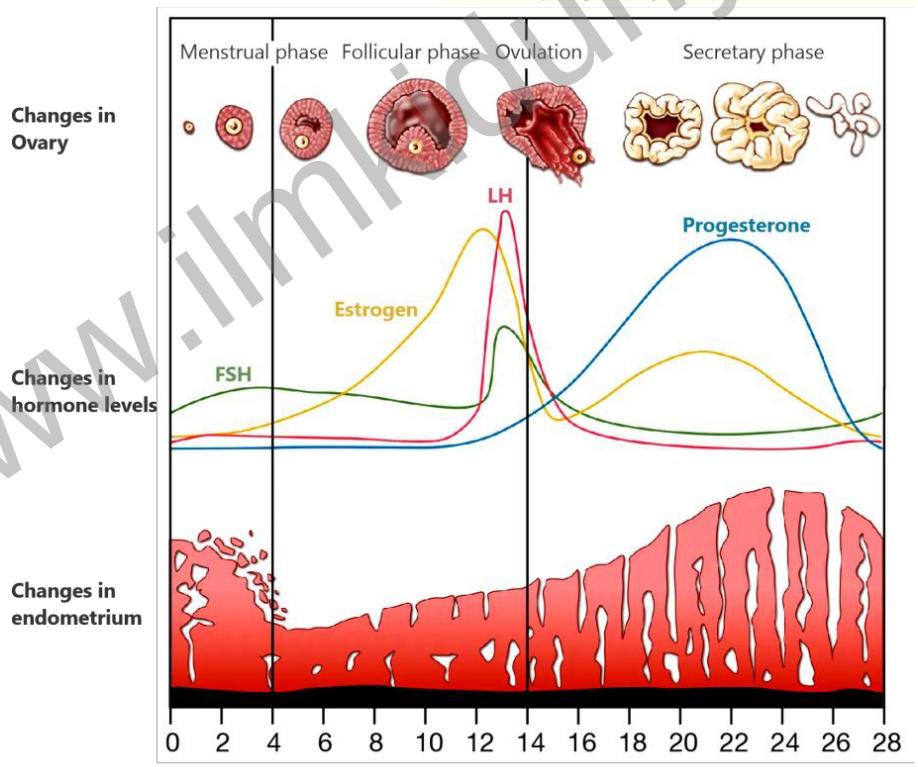

Figure 17.7: Menstrual cycle

EXERCISE

SECTION 1: MULTIPLE CHOICE QUESTIONS

1. Fertilization of the ovum occurs in:
   (a) Oviduct (b) Uterus (c) Cervix (d) Vagina
2. Which cells of the testis secrete testosterone hormone?
   (a) Sertoli cells (b) Germline cells (c) Spermatogonia (d) Leydig cells
3. The site of the production of sperm is:
   (a) Seminiferous tubules (b) Epididymis
   (c) Seminal vesicle (d) Vas deference
4. Which part produces fructose-rich fluid for the sperm?
   (a) Prostate gland (b) Seminal vesicles
   (c) Testis (d) Bulbourethral gland
5. In males, which hormone initiates spermatogenesis?
   (a) Luteinizing hormone b) Follicle stimulating hormone
   (c) Gonadotropin-releasing hormone (d) Testosterone
6. During ovulation which cell is actually released from ovary?
   (a) Oogonium (b) Primary oocyte
   (c) Secondary oocyte (d) Mature ovum
7. Which hormone stimulates the Graafian follicle to release ovum?
   (a) LH (b) FSH
   (c) Estrogen (d) Progesterone

SECTION 2: SHORT QUESTIONS

1. Briefly describe the function of seminal vesicles, prostate gland, and bulbourethral glands.
2. When do the ova in a females begin meiosis? When do they complete the first meiotic division?
3. Write a brief note on the role of FSH, LH and testosterone in man.
4. List the structures of female reproductive system.
5. What changes occur in ovulation and menstruation during gestation period.
6. What is the role of the corpus luteum in a menstrual cycle?
7. Differentiate between:
   - Primary and secondary spermatocytes
   - Spermatogenesis and oogenesis
   - Sertoli cell and Leydig cell
   - Spermatids and spermatozoa

- Primary oocyte and secondary oocyte

SECTION 3: LONG QUESTIONS

1. Describe the structure of human male reproductive system. Identify the function of each part.
2. Explain the major reproductive hormones of human male and explain their role.
3. Explain the structures of human female reproductive system. Identify the function of each part.
4. Describe the events of a menstrual cycle and explain its hormonal regulation.

INQUISITIVE QUESTIONS

1. List the structures in order, through which a sperm passes on its way from the seminiferous tubules to the outside.
2. Describe the effect of endocrine disrupting contaminants on the reproductive abilities.
3. Why are so many sperms produced in the male and so few ova produced in the female?