

CHAPTER-7

The Reproductive System

Learning Outcomes:

The student should be able to:

- Describe the anatomy of the structures.
- Discuss the functions of the various organs and tissues of the reproductive system.



The essential organs of reproduction:

Male:

Testes – producing the spermatozoa, hormones and secondary sexual characteristics.

Female:

Ovaries - producing the ova, hormones and secondary sexual characteristics.

Secondary organs of reproduction:

Male:

- The scrotum, which houses the testes
- A system of ducts, the efferent ductules, the epididymis, ductus deferens, ejaculatory ducts which conveys the sperm from the testes to the urethra.
- A number of glands – the seminal vesicles, prostate and bulbourethral glands, which secrete fluids.
- A copulatory organ – the penis, which transfers spermatozoa into the female reproductive tract.

Female:

- The uterine tubes (fallopian tubes), which receive and transmit the ova.
- The uterus, in which the embryo and foetus are housed and nourished during development.
- A vagina, which serves as a passage from the external environment to and from the uterus.
- External structures include – the vulva, which consists of the mons pubis, clitoris, the labia majora and minora, a thin membrane called the hymen, which partly closes the external orifice to the vagina.
- Glands include the greater vestibular glands (Bartholin's glands) and mammary glands.

The Perineum

- This region includes all the structures between the symphysis pubis and the coccyx.

- It is divided into two triangular portions:
- The anterior triangle contains the external urinary and reproductive structures- the urogenital triangle.
- The posterior triangle containing the anus is called the anal triangle.

The Female Reproductive System

The ovaries

These are a pair of paired, oval and nodular glands, about 3-4cm in length and less than 1cm thick. The ovaries are located on either side of the uterus, and are attached to the posterior side of the broad ligament of the uterus by a double layered fold of the peritoneum- the mesovarium. Between the two layers, blood vessels and nerves pass to reach the hilus of the ovary. The ovaries are further attached to the uterus by the ovarian ligament and to the pelvic walls by the suspensory ligament.

Micro-anatomy of the ovaries

- The germinal epithelium- a layer of simple cuboidal or squamous epithelium which covers the surface of the ovary.
- The tunica albuginea- is a white capsule of dense irregular connective tissue deep to the germinal epithelium.
- The ovarian cortex- deep to the tunica albuginea, contains the ovarian follicles.
- The ovarian medulla- deep to the ovarian cortex, and contains blood vessels, lymphatics and nerves.
- The ovarian follicles- are little sacs, which lie in the cortex and consist of oocytes in various stages of development. Surrounding cells nourish the oocyte, and secrete oestrogen. These are termed follicular cells when they form a single layer, and are termed granulosa cells, when they form several layers.
- A mature Graafian follicle is a large, fluid filled follicle, which ruptures, expelling the secondary oocyte during ovulation. Some women experience this process as a severe pain for several hours and this pain is referred to as Mittelschmerz.
- The corpus luteum (the yellow body) contains the remains of an ovulated mature follicle. It produces progesterone, oestrogen, relaxin and inhibin, until it degenerates into a corpus albicans.

The Uterine Tubules

These tubes are also known as **fallopian tubes**, or the oviducts. These are a pair of tubes which extend laterally from the supero-lateral angles of the uterus and lie within the folds of the broad ligament of the uterus, functioning to transport secondary oocytes and fertilized ova from the ovaries to the uterus.

The tubes are divided into three portions

- 1) **The isthmus**
- 2) **The ampulla,**
- 3) **The infundibulum** – a funnel-like structure formed by many branched processes, the fimbriae. The fimbria spread over the medial free edge of the ovaries – one of which are attached to the lateral end of the ovary.

Microscopic Structure and Function of the Fallopian Tubes

Consists of three coats:

- 1) **The outer, serous coat** – Serous membrane from the mesosalpinx.
- 2) **The middle, muscular layer** – An outer longitudinal layer, and an inner circular or spiral layer.
- 3) **An inner, mucous coat** - Simple columnar epithelium. The mucosa is deeply folded.

Some of the epithelial cells of the mucosa are ciliated. The cilia beat towards the uterus, and along with contractions of the muscular coat, to help transport the ovum to the uterus.

After ovulation, the fimbria, sweep the secondary oocyte from the celum into the uterine tube. In order to fertilise the ovum, the sperm cells need to swim against this ciliary current to reach the ampulla of the uterine tube, where fertilisation takes place. Several hours after fertilization, the nuclear material of the haploid ovum and the sperm unite, and the diploid ovum is now called a zygote.

Practical Implications: since there is a space between the ovary and the uterine tube, it is possible for the ova and sperm not to enter the uterine tube, but to become fertilised and implant into the peritoneum of the abdominal wall or viscera. These embryos usually die due to lack of nourishment and oxygen, however, some have reached full term and delivered surgically. This is known as an **ectopic pregnancy**. More commonly, the fertilised ovum fails to reach the ovum and implants into the wall of the uterine tube. These usually terminate with the uterine tube rupturing, or with the embryo being extruded into the abdominal cavity through the infundibulum.

The Uterus

The uterus is a single, hollow thick-walled, pear-shaped muscular organ.

Functions

- 1) A pathway for sperm to reach the uterine tubes
- 2) The site of menstruation
- 3) Site of implantation of a fertilised ovum, development of the foetus and labour.

The uterus can be divided into three portions

- 1) **The Fundus** - Lies superior to the points of entrance of the uterine tubes.
- 2) **The Body** - Lies anteflexed (bent) and antiverted (tilted) over the bladder.

3) **The Cervix** - Inferior to the body. With an internal os, the canal of the cervix and an external os, leading into the vagina.

Note: Although the uterus is held within its limits by the ligaments, it is actually supported by the pelvic floor, and the surrounding organs. A weakened pelvic floor may cause the organ to descend, and this is referred to as a prolapsed uterus. The ligaments maintain the uterus in the normal antiflexion position, however, they may allow for retroflexion – which may be normal and unimportant, or it may predispose to prolapse.

The main ligaments holding the uterus in position are the following:

- 1) The broad ligament – A double fold of peritoneum, enclosing the uterus, uterine tubes, the round ligament and the ovaries.
- 2) The round ligaments – Extend from inferior to the uterine tubes to a portion of the labia majora.
- 3) The suspensory ligament – Between the lateral aspect of the ovary and the peritoneum wall.
- 4) The ovarian ligament – Between the medial aspect of the ovary, and the uterine body.

Microscopic Anatomy of the Uterus

The walls of the uterus are made up of three coats, similar to those of the fallopian tubes, with which they are continuous.

1) **The Endometrium:**

- The inner mucous membrane coat, and the layer subject to the greatest changes.
- The endometrium has a surface covering of simple columnar epithelium with scattered cilia, which beat towards the vagina.
- Simple and branched tubular glands (secretory) are abundant and extend into the highly vascular and cellular lamina propria (the endometrial stroma.)
- Lymphatics are abundant.

The endometrium is divided into two layers:

- a) The **stratum functionalis** – lines the uterine cavity and is shed during menstruation.
- b) The deeper **stratum basalis**, which is permanent and give rise to a new stratum functional after each menstruation.

2) The **myometrium:**

- This thick coat is composed of three layers of smooth muscle fibres, interspersed with fibrous and elastic connective tissue. It is highly vascular.

3) The **perimetrium:**

- This outer serous coat is derived from the visceral peritoneum, which covers most of the uterine surface, except for the cervix.

Blood supply to the uterus

Branches of the internal iliac artery form the uterine arteries. Tributaries of the uterine artery, called the arcuate arteries are arranged in a circular fashion

within the myometrium and give off radial arteries. The radial arteries penetrate deep into the myometrium, and divided into two types of arteriole:

- 1) **The straight arterioles** – Supply the stratum basalis
- 2) **The spiral arterioles** – Supply the stratum functionalis

This lush blood supply is needed to support the regeneration of the stratum functionalis after menstruation, implantation of a fertilised ovum and the development of the placenta. The blood is drained by the **uterine veins** into the **internal iliac veins**.

Endometrial changes during Menstruation:

The menstrual cycle starts at puberty with the onset of oestrogen and progesterone hormonal secretions by the ovary.

The menstrual cycle is divided into four phases:

- 1) **Menstruation** – Days 1-5 is considered as phase one, but will be described last.
- 2) **Repair** – Days 4-6.
Before menstruation has completely ceased, repair begins under the influence of oestrogen from the ovary, where follicular development is under way again. Epithelial cells from the uterine glands move out to cover the denuded areas.
- 3) **Proliferation** – Days 7-15.
With increased production of oestrogen by the ovarian follicles, the growth of the endometrium accelerates. The uterine glands lengthen and produce a thin secretion. The endometrium approaches 2mm in thickness.

Ovulation takes place.

- 4) **Secretion** – Days 16-28.
Progesterone from the corpus luteum begins to dominate. Due to the diminished influence of oestrogen, the thickening of the endometrium may be temporarily stopped, and sometimes there is inter-menstrual bleeding. The endometrium more than doubles in thickness during this period, reaching 4-5mm in thickness. The glands become long, swollen and tortuous, and produce a thick, mucoid secretion, rich in glycogen. Convoluted arterioles push into the outer layers of the endometrium and develop into coiled arterioles, which have longitudinal bands of smooth muscle below their tunica intima.

The uterus is ready to receive an embryo.

If implantation takes place, the endometrium continues to develop and the corpus luteum persists. In the absence of an embryo, the corpus luteum begins to degenerate, and this is a 'signal' for the endometrium to break down. The coiled arterioles of the outer endometrium contract and deprive the superficial layers of blood and oxygen.

5) Menstruation – Days 1-5.

Progesterone secretion declines as the corpus luteum begins involution, and the walls of the capillaries and some of the coiled arterioles break down, and blood escapes into the stroma of the superficial layers of the endometrium. Pieces of the superficial layer break away. The stratum basalis, having a conventional blood supply, remain intact and ready to start repair and replacement.

The Vagina:

The vagina functions as the entry and exit for menstrual flow, childbirth and semen. It is a fibromuscular structure, about 8-10cm long. The vagina is attached superiorly to the uterus at the cervix. The mucosa of the vagina is continuous with that of the uterus but epithelial cells differ.

The mucosa is made up of non-keratinized stratified squamous epithelium and areolar connective tissue, which lies in a series of transverse rugae. The mucosa contains large stores of glycogen, and decomposition of which results in organic acids. The acid environment retards microbial growth, and is harmful to sperm.

The muscularis is composed of an outer circular layer and an inner longitudinal layer of smooth muscle. The muscle layer is stretchy to accommodate the penis and delivery of a child.

The adventitia consists of areolar connective tissue, and anchors the vagina to the adjacent layers such as the urethra and urinary bladder anteriorly and the rectum and anal passage posteriorly.

The External Genital Organs:

These organs are collectively known as the **vulva** or **pudendum**.

- **The mons pubis** – is a fatty eminence in front of the symphysis pubis, which acts as a cushion to the bone.
- **The labia majora** – are homologous to the scrotum in the male. The labia are composed of areolar tissue, fat and muscle resembling the dartos of the scrotum.
- **The labia minora** – are two small folds lying between the labia majora. Anteriorly, they encircle the clitoris. These folds of skin have few sudoriferous glands, and many sebaceous glands. They are homologous to the spongy urethra of the penis.
- **The clitoris** – is an erectile organ, which is homologous to the penis. Although the clitoris is constructed like the penis, it has only two corpora cavernosa, which are enclosed in the connective tissue, and partly separated by a septum. The free extremity of the clitoris is the glans clitoris, which contains erectile tissue.
- **The vestibule** - is the cleft between the labia minora and behind the clitoris. It contains the orifice of the urethra anteriorly, and that of the vagina posteriorly. It is homologous to the membranous urethra of the male.

On either side of the external urethral orifice are the openings of the ducts of the paraurethral glands – which are embedded into the wall of the urethra and secrete mucus. They are homologous to the prostate gland.

- **The greater vestibular glands (Bartholin's glands)** – are situated on either side of the vaginal orifice to the ends of the bulb of the vestibule. Each has a duct, which opens between the hymen and the labia minora. These glands are the homologous of the bulbourethral glands of the male and secrete a lubricating substance.

The Mammary Glands

The breasts are modified sudoriferous glands, which produce milk. They lie over the pectoralis major and serratus anterior muscles, and are attached to them by a layer of deep fascia that is made up of dense connective tissue.

Each breast has one pigmented projection – the nipple, which has a series of milk secreting ducts called the lactiferous ducts. The pigmented area surrounding the nipple is referred to as the areola. The roughness of the appearance is due to a number of modified sebaceous glands. These glands secrete a saliva-resisting lubricant to protect the nipple during nursing. Erection of the nipple during tactile stimulation is due to the contraction of circular and radiating smooth muscle bundles.

The breast is supported by suspensory ligaments of the breast (Cooper's ligaments), which are located between the skin and deep fascia. With time and strain such as jogging or high impact aerobics, or not using a bra- the support of these ligaments is relaxed and 'Coopers droop' results.

Each gland consists of about twenty irregular lobes of secreting tissue, within adipose tissue. The lobes pass in a radial direction from the nipple to embed in the connective adipose tissue of the superficial fascia.

Each lobe is divided into several smaller compartments called lobules – which in turn are composed of clusters of the milk secreting alveoli glands. Surrounding the alveoli are spindle shaped cells called myoepithelial cells, the contraction of which aids the propulsion of milk towards the nipple. Milk passes from the alveoli into a series of secondary tubules and then into the mammary ducts. Near the nipple, the mammary ducts expand to form sinuses called lactiferous sinuses, where some of the milk is stored before draining into a lactiferous duct.

Milk production is stimulated largely by the hormone prolactin, with oestrogen and progesterone contributing to production. The ejection of milk is stimulated by oxytocin – which is released from the posterior pituitary gland in response to the infant suckling.

The Male Reproductive System

The Scrotum

This is the sac of loose skin and superficial fascia which supports the testes. It is divided superficially into two lateral portions by the raphe – a median ridge or seam, and each portion contains a single testis, epididymus and associated structures. Within the superficial fascia of the scrotum, lies involuntary muscle called the dartos. This muscle regulates the temperature of the testes by contracting in cold conditions and relaxing in warm conditions. The temperature of the testes is kept at 2-3 degrees below normal – for optimum sperm production. Another muscle – the cremaster muscle, is a band of skeletal muscle in the spermatic cord which elevates the testes on exposure to cold and during sexual arousal.

The Testes:

The testes are a pair of oval glands about 4-5cm long. The testicles descend through the inguinal canals before birth. As they descend, they become invested in various coverings derived from the layers of the body wall.

Coverings of the testes:

- 1) The **tunica vaginalis** - A serous membrane, is derived from the peritoneum, and partially covers the posterior portion of the testes.
- 2) The **tunica albuginea** - A dense fibrous capsule, which extends into the testes to divide the glands into septa called lobules.

There are about 200-300 lobules containing one to three tightly coiled tubules – the seminiferous tubules – where the sperm cells are produced. Each of these tubules are about 70-80cm in length – which averages about half a mile of tubules in each testis!

Sperm production begins in stem cells (spermatogonia), which line the periphery of the seminiferous tubules.

Among the spermatogenic cells, are Sertoli cells, extending from the basement membrane to the lumen of the tubule. The Sertoli cells join by tight junctions to form the blood-testis barrier. This barrier prevents an immune response against the spermatogenic cell's surface antigens, which are recognised as foreign by the immune system.

Sertoli cells function to support and protect developing spermatogenic cells by nourishing the cells, phagocytosing excess spermatid cytoplasm, controlling the movement of the spermatogenic cells, and releasing of sperm into the lumen of the seminiferous tubules. They also produce fluid for transport, and secrete androgen binding protein and the hormone inhibin. Between the adjacent seminiferous tubules are clusters of Leydig cells, which secrete testosterone.

The sperm cell (spermatozoon) consists of a head – which contains the nuclear material DNA, and an acrosome – enzymes, which aid penetration into the oocyte. The mid-piece carries the mitochondria – which metabolise ATP for the locomotion, and a flagellum or tail, which propels the sperm.

The Ducts of the Testis:

The sperm is released into the lumen of the convoluted seminiferous tubules, and is propelled toward the straight tubules (tubuli recti). From here, they move into a network of ducts called the rete testis, and then into the coiled efferent ducts of the epididymis, and then the sperm are emptied into a single tube called the ductus deferens.

The Epididymis:

The epididymis is the principal store-house of the sperm cells. It is a long comma shaped organ, which lies posterior to the testis. It is made up of a tightly coiled ductus epididymis. The head is the large, superior portion of the epididymis – where the efferent ducts from the testis joins the ductus epididymis. The ductus epididymis is a tightly coiled tube, and lined by pseudostratified columnar epithelium and encircled by layers of smooth muscle. The free surfaces of the columnar cells contain microvilli called stereocilia – which increase the surface area for re-absorption of degenerated sperm.

The body is the narrow mid-portion, and the tail is the narrow, inferior end, which continues on as the ductus deferens (otherwise known as the vas deferens).

The epididymis functions to store the sperm, and is a place where sperm motility increases over a 10-14 day period. It also helps to propel the sperm by peristaltic movements of its smooth muscle into the ductus deferens.

The Spermatic Cord

This cord is made up of the ductus deferens, the testicular artery, veins – which drain the testes and carry testosterone into the circulation, lymphatics, the autonomic nerves, and the cremaster muscle.

The cord passes through the inguinal canal. This canal is an oblique passage in the anterior abdominal wall – just superior to the medial half of the inguinal ligament. It originates at the deep inguinal ring – a slit-like opening of the transversus abdominis muscle, and ends at the superficial inguinal ring – a triangular opening of the external oblique muscle.

The Ductus Deferens and Seminal Vesicle

The ductus (vas) deferens is a continuation of the ductus epididymis. It ascends and passes through the inguinal canal, entering the peritoneal cavity, where it joins the duct of the seminal vesicle to form the ejaculatory duct, which enters into the prostatic urethra.

The ductus deferens is lined with pseudostratified columnar epithelium and two layers of longitudinal muscle, and a middle circular layer. The ductus deferens functions to store the sperm for up to several months, as well as propelling sperm towards the urethra by peristaltic contractions.

The seminal vesicles lie laterally to the ductus deferens on the posterior side of the bladder. They are coiled pouches, which secrete a fluid to add to the secretions of the testes.

The seminal vesicles secrete an alkaline fluid, which contains fructose, clotting proteins, and prostaglandins. The alkaline fluids help to neutralise the acidic environment of the female reproductive tract, and in the male urethra, caused by residual urine, that would otherwise kill sperm. The fructose is used for ATP production. Fluid secreted by seminal vesicles contributes to 60% of the volume of semen.

Ejaculatory Ducts:

Each duct is about 2cm long and is formed by the convergence of the seminal vesicle with the ampulla of the ductus deferens. They lie superior to the prostate gland, and pass through the prostate gland, where they terminate in the prostatic urethra. Here they ejaculate sperm and seminal vesicle secretions just before ejaculation.

The Urethra:

The urethra is the shared duct of the reproductive and urinary systems. It is subdivided into three portions:

- 1) The prostatic urethra – 2-3cm long, passes through the prostate gland.
- 2) The membranous urethra – 1cm, passes through the genital diaphragm.
- 3) The spongy urethra – 15-20 cm long – passes through the corpus spongiosum of the penis.

The Prostate Gland:

This is a single gland the size of a chestnut, which lies inferior to the bladder and surrounds the urethra. It secretes a milky, slightly acidic substance which is used by sperm for APT production in the Krebs cycle. The secretions of the prostate gland, which make up about 25% of the semen volume, enter the urethra via the many prostatic ducts and contribute to sperm mobility and viability.

The Bulbourethral Glands:

These glands are about the size of a pea and are situated on either side of the membranous urethra, inferior to the prostate gland, within the urogenital diaphragm. During sexual excitement, the glands secrete an alkaline substance, which protects the sperm from the acid environment formed by residual urine in the urethra. These glands also secrete mucus which functions to lubricate the end of the penis and the lining of the urethra, thus decreasing sperm damage during ejaculation.

Semen:

Means 'seed', and is a mixture of the sperm and the fluid secreted from the seminiferous tubules, seminal vesicles, prostate gland and bulbourethral glands. The typical volume with each ejaculation is between 2.5 – 5ml – with a sperm count of 50-150 million sperm per ml. Below 20 million per ml is considered infertility.

Semen has an alkaline pH of 7.2 – 7.7, despite the acid medium of prostatic fluid. The function of seminal fluid is to provide the sperm with transportation medium, nutrients, and to neutralise the acid environment of the male urethra and vagina. It also contains seminalplasmin, an antibiotic which probably

helps to control bacterial populations of the semen and the lower female reproductive tract.

The Penis:

The penis contains the urethra, and is the passage for the ejaculation of semen and the excretion of urine.

Consists of:

- a) **The body**
- b) **The root**
- c) **The glans penis.**

The body of the penis is composed of 3 cylindrical masses of tissue, each surrounded by the fibrous tissue of the tunica albuginea.

The pair of dorsolateral masses are called the corpus cavernosa penis (hollow)

The smaller midventricular mass is called the corpus spongiosum penis – which contains the spongy urethra. This body keeps the spongy urethra open during ejaculation

All three masses are enclosed by fascia and skin, and consist of erectile tissue permeated by blood sinuses.

During sexual stimulation, the parasympathetic reflex causes the arteries supplying the penis to dilate, allowing large quantities of blood to flow into the blood sinuses of the body. This expansion of tissue compresses the veins, which drain the penis, slowing the blood outflow. The sympathetic reflex results in ejaculation, and also the constriction of the smooth muscle sphincter at the base of the urinary bladder, thus preventing the flow of urine into the urethra and semen into the bladder. Before ejaculation, peristaltic contractions in the ampulla of the ductus deferens, seminal vesicles, ejaculatory ducts, and prostate gland, propel semen into the penile portion of the urethra. This is called emission, and occurs prior to ejaculation, and may occur at during sleep.

The root (attached portion) of the penis consists of:

- 1) **The bulb** – This is the expanded portion of the corpus spongiosum penis. This is attached to the inferior surface of the urogenital diaphragm, and enclosed by the bulbospongiosus muscle.
- 2) **The crura** of the penis (legs) – which is the two separated and tapered portions of the corpora cavernosa penis. Each crus is attached to the ischial, and inferior pubic rami and is surrounded by the ischiocavernosus muscle. Contraction of the above muscles aids ejaculation.

The Glans penis- is the distal end of the corpus spongiosum. It is surrounded by a margin called the corona. The distal urethra enlarges to form a slit-like opening of the external urethral orifice. Covering the glans is the prepuce. The weight of the penis is supported by two ligaments which are continuous with the fascia of the penis – the fundiform ligament, which arises from the inferior aspect of the linea alba. The suspensory ligament which arises from the symphysis pubis.

The reproductive systems

SELF ASSESSMENT QUESTIONS

Question 1:

Describe the route that the sperm cell takes from release into the seminiferous tubules to ejaculation.

Question 2:

Describe the anatomy of the penis.

Question 3:

Name the four ligaments holding the uterus in position.

Question 4:

Please fill in the missing words.

The uterus is lined by three coats of tissue. The inner mucous membrane is called the, and the layer subject to most change. This layer is divided into two layers, the stratumis shed during menstruation, and the deeper stratumwhich is permanent. The middle coat is composed of smooth muscle fibres, is referred to as the, and the outer coat, which is derived from the peritoneum is called the

Question 5:

Link the following words with the most appropriate phrase:

- | | |
|-----------------|---|
| 1) Menstruation | a) Rupture of the Graafian follicle |
| 2) Ovulation | b) Shedding of the stratum functionalis |
| 3) Progesterone | c) Cervical fluid less viscous |
| 4) Ovulation | d) Corpus luteum |

Please refer to your labelling supplement handbook and label any images associated with the above chapter.

