UNIT 4  REPRODUCTIVE BIOLOGY

Contents

4.1 Introduction
4.2 The Reproduction System
4.3 Reproductive Physiology of Male and Female
4.4 Organs of Male Reproductive System
4.5 Organs of Female Reproductive System
4.6 Physiology of Male Reproductive Process
4.7 Physiology of Female Reproductive Process
4.8 Biological Aspects of Human Fertility
4.9 Relevance of Menarche
4.10 Relevance of Menopause
4.11 Other Bioevents to Fertility
4.12 Summary

Suggested Reading
Sample Questions

Learning Objectives 📚

After going through this unit, you should be able to:

- understand aspects of the reproductive physiology of male and female;
- learn the biological aspects of human fertility;
- highlight the differences between menarche and menopause; and
- indicate other biological issues related to fertility.

4.1  INTRODUCTION

In this unit we are going to understand about reproductive biology of males and females, the biological factors related to human fertility and about menarche and menopause. We will also study other bio events related to human fertility.

Now let us try to understand about the phenomenon of reproduction among human beings. Reproduction is one of the essential characteristics of life. It is illustrated in its primitive form by the action of single–celled amoeba in dividing into two. Most of the cells of the human body have the same power of division by virtue of which growth and repair are possible.

Reproduction in man and other higher animals is a complex process involving the existence of two sexes, both of which play their respective roles in the formation of a new individual, i.e. offspring.

The reproductive organs of the male and female differ in anatomical structure and arrangement, each having functional specificities required for reproduction. The function of the male organs is to form spermatozoa or sperms and implant
them within the female so that they can meet the ova. The female organs are adapted to form ova or eggs which, if fertilized by spermatozoa, remain in the cavity of the uterus. Here an embryo or fetus is formed and is retained until the individual grown in the uterus is capable of a separate and independent existence.

4.2 THE REPRODUCTION SYSTEM

Evolutionary biology clearly indicates that the sexes are separate among human beings. As such the reproductive systems are separate and function independently. Both male and female reproductive systems function with the help of different hormones secreted by different glands, thereby they are responsible for different functions and carry out reproductive process in a successful manner.

4.3 REPRODUCTIVE PHYSIOLOGY OF MALE AND FEMALE

Before actually knowing about the reproductive physiology of males and females it is better to understand the different reproductive organs involved in it. In this sub unit we can discuss about the reproductive physiology of male and female briefly.

Human beings are bi-sexual organisms wherein sexes are separate and as such they have separate sex organs and these sex organs are specialised for carrying out certain functions. In both the sexes, different organs are meant for different functions in reproductive process. In subsequent sub-units we are going to discuss about the structure of male and female sex-organs, the related endocrine secretions and their functions in the process of reproduction in brief.

4.4 ORGANS OF MALE REPRODUCTIVE SYSTEM

The male reproductive system includes the primary sex organs and accessory sex organs. Primary sex organs are testes and the accessory sex organs are seminal vesicles, prostate gland, urethra and penis.

Testis

Testis is the primary male sex organ or male gonad. It corresponds with ovary in females. There are two testes (singular = testis) in almost all the species. Each testis contains about 900 coiled tubules known as seminiferous tubules. The seminiferous tubules produce sperms. The sperms enter the vas deferens, which form the epididymis. It is continued as vas deferens.

Seminal Vesicles

The seminal vesicles are accessory sex organs in males, which are situated on either side of prostate. Secretions of seminal vesicles are emptied into ampulla of vas deferens. The enlarged portion of vas deferens is called ampulla. The ampulla of the vas deferens is continued as ejaculatory duct, which passes through prostate to form internal urethra.
Prostate Gland

Prostate gland is also an accessory sex organ formed by numerous secretory glands. Secretion from prostrate glands follows the path to utriculus prostaticus and is then emptied into internal urethra.

Urethra

Urethra has two parts namely, internal urethra and external urethra. Internal urethra is the continuation of ejaculatory duct. Internal urethra passes through penis as external urethra. Urethra contains mucus glands throughout its length, which are called glands of litter. The bilateral bulbourethral glands also open into the urethra.

Penis

Penis is the male genital organ formed of three erectile tissue masses, i.e., a paired corpora cavernosa and an unpaired corpus spongiosum. The urethra passes through penis and opens to the exterior and the spongiosum surrounds the urethra and terminates distally to form glans penis.

Structure of Testis

The testes are ovoid or walnut shaped bodies having the organisation of compound tubular gland. Both the testes are located in the sac like structure called scrotum.

Functions of Testis

- The gametogenic function and
- Endocrine function

The production of gamete cells is called the gametogenic function. Spermatogenesis is the process by which spermatozoa are developed from the primitive germ cells in the testis known as spermatogonia. Spermatogenesis occurs in four stages.

1) Stage of proliferation
2) Stage of growth
3) Stage of maturation and
4) Stage of transformation

Now, we can discuss about how spermatogenesis takes place.

1) Stage of Proliferation

The spermatogonia near the basement membrane of seminiferous tubule are larger. Each one contains diploid number of chromosomes (23 pairs in human males). One member of each pair is from maternal origin and the other from paternal origin.

During the proliferative stage, the spermatogonia divide by mitosis without any change in chromosomal number. In human male, there are usually seven generations of spermatogonia. The last generation enters the stage of growth as primary spermatocyte.
2) Stage of Growth
The primary spermatocyte grows into the large cells. Apart from this, there is no other change in this stage.

3) Stage of Maturation
After reaching the full size, each primary spermatocyte quickly undergoes meiotic or maturation division, which occurs in two stages. In the first stage, two secondary spermatocytes are formed. In the second stage, each secondary spermatocyte divides into two spermatids. The significance of the two stages of maturation division is that, each spermatid receives only the haploid or half the number of chromosomes.

4) Stage of Transformation
The spermatids do not divide further but transform into spermatozoa by a process called spermatogenesis.

4.5 ORGANS OF FEMALE REPRODUCTIVE SYSTEM

Now we can try to understand about the female reproductive organs; specifically their structure and functions. The female sex organs are situated in the pelvis and for purposes of description may be divided into:

i) Internal organs: uterus, ovaries, fallopian (uterine) tubes, vagina

ii) External organs: mons veneris, labia majora and minora, clitoris, hymen

iii) Secondary organs: the breast or mamae (mammary glands).

*Internal organs*

In the following paragraphs you will briefly know about the female reproductive organs, their structure and functions.

*The Ovary*

There are two ovaries (female gonads), right and left, lying on each side of the upper pelvic cavity situated against the pelvic wall near the uterus. Each is about the size of a large almond and is attached to the posterior aspect of the broad ligament of the uterus by a fold of peritoneum. It lies immediately below the fallopian tube which forms an arch over the top of the ovary and ends just below its lateral margin.

*Structure*

Briefly the ovary may be described as having (i) a medulla in the centre consisting mainly of fibrous tissue or stroma, and (ii) a cortex on the surface consisting of a layer of epithelium (the germinal epithelium), a number of cystic spaces of various sizes – the Graafian follicles – which contain the ova surrounded by a little fluid, and a yellow body – the corpus luteum – formed after a Graafian follicle has ruptured and discharged its contained ova and fluid.
Functions

i) To produce ova.

ii) The Graafian follicle secretes the hormone oestrogen

iii) The corpus luteum secretes the hormone progesterone.

The Fallopian Tube

The fallopian tubes, two in number, named after the 16th century Anatomist, Fallopins, are about 10 cm (4 inch) in length and lie in the upper margin of each broad ligament of the uterus, thus being surrounded by peritoneum. The outer end of the tube is expanded and has an opening into the peritoneal cavity. This is surrounded by a number of fringes – like processes, the fimbriae, which lie close to the lateral part of the ovary. It has already been seen that the middle of the tube curves round the ovary like an arch.

Structure

The fallopian tube has a muscular wall continuous with that of the uterus. Its outer surface is covered by peritoneum, while its inner lining or mucous membrane is formed of ciliated epithelium.

Function

Its function is to collect the ova discharged from the ovary in its fimbriated end, and pass them along its interior towards the cavity of the uterus by the action of its ciliated epithelium. Fertilization of the ovum by spermatozoa usually takes place in the tube.

The uterus

The uterus (womb) is a hollow, pear-shaped organ situated in the pelvic cavity above the urinary bladder and in front of the rectum. It has thick muscular walls and a small central cavity. In the nulliparous women (those who have never borne a child) it measures about 7.5 cm (3 in) in length, 5 cm (2 in) in width and 1.75 cm (1 in) in thickness. In multiparous (those who have previously borne children) the uterus is still larger and its shape remains variable.

The uterus consists of (i) the fundus, (ii) the body and (iii) the cervix. The fundus is the upper part of the uterus situated between the two fallopian tubes. The body forms the greater part of the organ and is the portion between the fundus and the cervix. The cervix or neck is the lowest portion, part of which projects like an inverted dome into the vagina below. It is traversed by a canal opening above into the cavity of the uterus by an orifice called the internal os, and below into the vagina by the external os.

Attached to either side of the fundus of the uterus are the hollow fallopian tubes (oviducts). The cavity of the uterus has, therefore, three openings – one into each fallopian tube and one through the external os of the cervix into the vagina.

The fundus, the body and the cervix, except for that part which projects into the vagina, are covered on their outer surface by peritoneum. The peritoneum on the anterior surface of the body of the uterus, if traced forward, is found to be reflected on to the superior surface of the bladder. That from the posterior surface lines the lowest part of the pelvic cavity before passing on to the rectum. This space between the uterus and the rectum is called the recto-uterine pouch of Douglas.
The peritoneum passing laterally from the uterus extends to the side wall of the pelvis. It consists of two layers, the front layer being continuous with the peritoneum covering the anterior surface of the uterus and the posterior layer with that covering the posterior surface of the uterus.

This double fold of peritoneum passing from the side of the uterus to the wall of the pelvic cavity is called the broad ligament. Between the two layers forming its upper margin is situated the fallopian tube. It is, therefore, rather like a piece of material draped to hang down on either side of a horizontal pole – the pole being represented by the curved fallopian tube. Also enclosed between the layers of the broad ligament is a fibrous band, the round ligament of the uterus which passes from the side wall of this organ to the inguinal canal.

Structure
The walls of the uterus consist of three layers:

i) The outer serous coat of peritoneum.
ii) The thick middle layer consisting of involuntary, plain muscle (myometrium)
iii) The inner mucous coat called the endometrium.

Functions
i) To receive the fertilized ovum and to retain and nourish the developing foetus throughout the duration of pregnancy.
ii) To expel the foetus at the end of pregnancy by the contractions of its muscular walls.
iii) To play a part in the phenomenon of menstruation.

The vagina
This is a canal with muscular walls 8-10 cm (3-4 in) long which passes in a downward and forward direction from the cervix of the uterus to its lower orifice in the vulva. It is normally collapsed, and the length and diameter of the vagina increased during sexual arousal. The main functions of vagina pertain to serve as the passageway for menstrual flow, as a receptacle for the penis during coital act, and as a part of birth canal.

It is lined by a thin type of skin which is thrown into a number of transverse folds and is kept moist by the secretion of the mucous glands present in the cervix. This secretion is slightly acid in reaction (due to lactic acid). The vagina is the natural home for several microorganisms. Out of these some of the bacteria, fungi and protozoa play important roles in maintaining the vaginal environment.

The breasts or mammary glands
The two breasts are glands which are accessory to the genital system, that is, they take no parts in the actual process of reproduction. They are present in an undeveloped form in the female before puberty as also in the male.

The fully developed female breast, while varying considerably in size, is circular in outline and approximately hemispherical in shape. It lies on the pectoralis major muscle, extending from the second rib above to the sixth rib below and from the margin of the sternum on its medial side to the axilla on the lateral side.
Just below the centre is a small elevation, the nipple, in which the ducts of the breast open. The nipple, in addition, contains a few plain muscle fibers which cause it to become erect when stimulated. The function of the breasts is to secrete milk during breastfeeding. It also serves as a stimulus for sexual arousal in both the sexes. These glands are actually evolved from sweat glands. In humans, though a single pair of breasts persists, in some individuals more than one pair is seen. This condition is called polythelia. It is to be noted that each human female breast is covered by skin and contains a variable amount of fat and the actual mammary gland tissue. The breast size and shape variation occurs due to differences in the amount of fat distribution. The quantity of milk secretion usually does not vary according to breast size.

4.6 PHYSIOLOGY OF MALE REPRODUCTIVE PROCESS

Now we can discuss the physiology of male reproductive process.

In the last sub unit i.e., 4.4 it is clear about the way how the process of spermatogenesis takes place and now we will see the role of hormones in the process.

The hormones which are necessary for spermatogenesis are:

i) Testosterone not only stimulates the process of spermatogenesis but is also necessary for the formation of secondary spermatocyte from primary spermatocyte.

ii) Follicle stimulating hormone (FSH) in addition to testosterone is also necessary for the stimulation of the process of spermatogenesis.

iii) Luteinizing hormone (LH) is essential for the secretion of testosterone from Leydig cells.

iv) Estrogen secreted by Sertoli cells is also necessary for the process of spermatogenesis.

v) Growth hormone (GH) is essential for the general metabolic processes in testis. It is also necessary for the proliferation of spermatogonia.

The above mentioned hormones act at different stages of spermatogenesis.

*Endocrine Function of the Testis*

Male sex hormones are called androgens. Testes secret three androgens,

i) Testosterone

ii) Dihydrotestosterone

iii) Androstenedione. Testosterone is secreted in large quantities by testes and by adrenal cortex in small quantity.

*Functions of Testosterone*

In general, testosterone is responsible for the distinguishing characteristics of masculine body. In the foetal life, the testes are stimulated by human chorionic gonadotrophins secreted by the placenta. But in childhood practically no testosterone is secreted approximately until 10–12 years of age. Afterwards the
testosterone secretion starts and it increases rapidly at the onset of puberty and lasts throughout most of the remaining part of the life. It is also essential for the growth of the external genitalia – penis, scrotum and other accessory sex organs – genital ducts, seminal vesicles and prostate.

4.7 PHYSIOLOGY OF FEMALE REPRODUCTIVE PROCESS

Before actually having a glance on female reproductive process we shall try to know about functions of the female reproductive organs. The functions of the female reproductive organs are directed to the following ends:

i) The formation of ova or ovulation.

ii) The preparation of the uterus to receive the fertilized ovum.

iii) The retention of the fertilized ovum within the cavity of the uterus until a mature foetus is formed, capable of leading an independent existence, i.e. pregnancy.

iv) The expulsion of the mature foetus, i.e. labour or parturition.

In the young female child, these processes are in abeyance. At a variable age, as a result of the activities of the ductless glands, preparation for the reproductive period in a woman’s life commences and is called puberty. The period during which reproduction is possible usually extends from the early teens until the age of forty-five to fifty, when it ends in the menopause (climacteric or ‘change of life’), after which pregnancy does not occur.

Ovulation

Now you will know about the ovulation and its role in reproductive process. The ovary contains many thousands of eggs or ova which lie dormant until the onset of puberty. Active changes then take place in the ovary which results in the periodic discharge of an ovum at intervals of a month.

A graafian follicle is a small cystic sac containing fluid and having the ovum attached to its wall, which comes gradually to the surface of the ovary and ruptures about two weeks after the commencement of the last menstrual period.

The ovum therefore actually passes into the peritoneal cavity but is soon caught up in the fimbriae of the fallopian tube which closely surround the ovary. By the action of the ciliated epithelium of the fallopian tube, the ovum is carried slowly towards the cavity of the uterus. Within or little over ten days this stage of journey of the ovum towards the uterine cavity is completed.

The ovum is either fertilized, in which case it becomes embedded in the wall of the uterus and commences to grow into an embryo; or else it is discharged unfertilized from the uterus in the menstrual flow.

Certain changes take place in a graafian follicle after its rupture and it becomes a solid yellowish body called the corpus luteum. This body goes on developing until the next menstrual period, when it gradually disappears and is replaced by fibrous tissue. If the ovum is fertilized, however, the corpus luteum persists throughout pregnancy and, it will be recalled, acts as a gland of internal secretion, producing the hormone progesterone.
Menstruation

Our next concern is to know about the relevance of menstruation. This is a function of the uterus established at puberty (average age, 12 to 13 years) as a result of ovarian activity and consists of the periodic discharge of blood from its cavity. It occurs on an average of every twenty-eight days until the menopause or climacteric is reached, and lasts for three to five days. The amount of fluid, which consists of blood, mucin and epithelial cells, varies between 90-200 ml (3-7 fl. Oz). Menstruation ceases during pregnancy and is often not reestablished until lactation is completed.

The purpose of the monthly cycle is to prepare the mucous membrane of the uterus (endometrium) to receive a fertilized ovum. The endometrium undergoes constant changes between one menstrual period and another and these changes are made in preparation to receive the fertilized ovum. They are largely brought about by the Follicle-Stimulating (FSH) and the Luteinizing (LH) hormones secreted by the pituitary gland, and by estrogen and progesterone secreted by the ovary. Menstruation is really a clearing up of these changes in the endometrium when no fertilized ovum has arrived, and therefore in this sense it gives the endometrium an opportunity to make a fresh preparation.

These changes are described as the menstrual cycle and may be conveniently divided in the following way:

1) The secretory (pre-menstrual) phase, lasting for about 14 days before the period, during which the endometrium becomes thickened and congested and is in a state of preparedness to receive a fertilized ovum.

2) The menstruation period (three to five days) in which some of the epithelium of the uterine mucosa is shed and is accompanied by bleeding. In other words, no fertilized ovum has been received and the work of preparation has been useless.

3) The stage of repair begins in the third or fourth days of the menstrual cycle.

4) The growth phase starts on the fourth day and continues up to fourteenth day before the next secretory phase.

4.8 BIOLOGICAL ASPECTS OF HUMAN FERTILITY

Before actually proceeding to know about the biological aspects of human fertility, it is essential to know about the definition of fertility. Fertility is generally indicated by the actual reproductive performance of a woman or group of women. At the same time, we should know about the other related term ‘fecundity’. Fecundity is the biological potential, i.e. the physiological capacity for reproduction. The absence of this potential is known as infecundity. Fertility can be described as the phenomenon of giving birth to children.

Now let us see how biological factors are responsible for the fertility among human males and females. Biological factors play a very important role in determining fertility. The onset of menarche in proper time, regular production of healthy ova, the production of sufficient number of healthy sperms among the males, etc. are important factors. The other biological factors influencing fertility
are health and disease, food habits, etc. Furthermore, genetic factors play an important role on human fertility, as well.

### 4.9 RELEVANCE OF MENARCHE

Now you will know about the importance of Menarche and its role in the reproductive process. Menarche is the first menstrual cycle, or first menstrual bleeding, in human females. From both social and medical perspectives it is often considered the central event of female puberty, as it signals the possibility of fertility. Girls experience menarche within a range of different ages after attaining puberty. The timing of menarche is influenced by female biology, as well as genetic and environmental factors, especially nutritional factors. The average age of menarche has declined over the last century but the magnitude of the decline and the factors responsible remain subjects of contention.

Menarche is the culmination of a series of physiological and anatomic process of puberty. During this period, a number of physiological changes occur in the girl’s body wherein secondary sexual characters appear. Menarche as a discrete event is thought to be relatively a chance result of the gradual thickening of the endometrium induced by rising but fluctuating pubertal estrogen.

Puberty signals the onset of adult sexual life, and menarche means the inception of menstruation. At the start of about 8 years and usually terminating at the onset of menstruation between ages 11 and 16 years i.e. at an average age of 13 years, there is a gradual increase in gonadotropic hormone secretion by the pituitary causing the period of puberty.

In the female, as in the male, the infantile pituitary gland and ovaries are capable of full function if appropriately stimulated. However, as is also true in the male and for reasons not understood, the hypothalamus does not secrete significant quantities of growth hormone during childhood. Experiments have shown that the hypothalamus itself is capable of secreting this hormone, but there is lack of the appropriate signal from some other brain area to cause the secretion. Therefore, it is now believed that the onset of puberty is initiated by some maturation process that occurs elsewhere in the brain, perhaps somewhere in the limbic system.

### 4.10 RELEVANCE OF MENOPAUSE

Now we can discuss about the menopause and its role in reproductive biology of human beings. Menopause is a period of permanent termination of the primary functions of the human ovaries, which are the ripening and release of ova and the release of hormones that cause both the creation of the uterine lining and later detaching of the uterine lining (a.k.a. the menses). Menopause is generally experienced in women during their midlife, which is late 40s or early 50s. This marks the end of fertile phase of a woman’s life.

There is major decline in the production of female hormones by the ovaries during the change from reproductive to non-reproductive phase. It is not abrupt but phases over a period of years and is accepted to be a natural consequence of ageing. However, variations in the transition phase have been observed amongst women. In some women the accompanying signs and effects can significantly
disrupt their daily activities and their sense of well-being. In addition, menopause at younger age is experienced by women who have some sort of functional disorder which affects their reproductive system (i.e., endometriosis, polycystic ovary syndrome, cancer of the reproductive organ). These functional disorders considerably hasten the menopausal process and result in health problems both physical and emotional in the affected woman.

Now we can see the changes that occur in the physiological and psychological aspects among the women. At this age, women should be ready to invite menopause by making their mind. In certain cases counseling is also necessary. At the time of menopause, a woman must readjust her life from one that has been physiologically stimulated by estrogen and progesterone production to one devoid of these hormones. The loss of the estrogens often causes marked physiological changes in the function of the body, including (1) ‘hot flushes’ categorized by extreme reddening of the skin, (2) psychic sensations of dyspnea, (3) irritability, (4) fatigue, (5) anxiety, (6) occasionally various psychotic states, and (7) decreased strength and calcification of bones throughout the body. In 15% of women, these symptoms are of adequate measure to warrant treatment. If counseling fails small quantities of estrogen reverses the symptoms and with gradual tapering of the dose the postmenopausal women is likely to avoid severe symptoms.

### 4.11 OTHER BIO-EVENTS TO FERTILITY

Here we can discuss the effects of few biological factors on human fertility. These factors include contraception, abortion and sterilization. All these factors are so important that these need careful study. In every society, now-a-days there is a tendency that family should be small, population explosion should be checked.

i) **Contraception**

Contraceptive practices affect fertility by decreasing the chance of conception. There is a considerable variation in the effectiveness of practicing contraceptive methods as projected in theory and while in actual use. Effective rates of more than 95% are reported using contemporary methods such as oral pills and intrauterine devices. Older methods such as condoms and diaphragm can be more than 90 per cent effective, when used regularly and correctly, but their average use effectiveness is lower because of irregular or incorrect use. Natural methods of contraception viz. withdrawal or abstinence are also in use with variable degree of effectiveness in human groups.

ii) **Abortion**

Induced abortion diminishes fertility by terminating pregnancy not by affecting fecundability. Practice of abortion in human societies dates back to ages and is rather common in some settings. Statistics reveal that officially registered percentage of pregnancies terminated by abortion is more than one-third in some countries and substantial numbers of unregistered abortions are perhaps prevalent even in countries where they report very low rate.

iii) **Sterilization**

The complete elimination of fecundability can be brought about by sterilization. The surgical procedures of tubectomy and vasectomy have become common in
Human Growth and Development

diverse nations and cultures. In USA voluntary sterilization has become the most prevalent single means of regulating fertility, typically adopted by couples who have achieved their desired family size. In India sterilization has been encouraged on occasion by various government run incentive programmes.

4.12 SUMMARY

Reproductive Biology is one of the important subjects in science. Evolutionary biology clearly indicates that the human beings are bi-sexual. As such both the sexes possess different reproductive system and function independently with the help of different hormonal secretions. To study both male and female reproductive systems, it is essential to understand the different organs of males and females. The physiological aspects of these two systems are also very important to understand their functions. Physiology of both male and female reproductive processes mainly involves the secretion of different hormones and their functions at different levels. In reproductive biological studies much emphasis has been laid on the term fertility. Fertility can be described as the phenomenon of childbearing. Both biological and non biological factors play an important role in determining fertility. At the same time we can put stress on two important terms mainly involved in the reproductive process, i.e., menarche and menopause. Menarche can be defined as the first menstrual cycle that a female experiences. Menopause is a term used to describe the permanent cessation of primary functions of the ovaries, thus terminating the reproductive capacity of the female. Contraception, abortion and sterilization are said to be the other factors that control or terminate the pregnancies.

Suggested Reading


Sample Questions

1) Describe the reproductive physiology of male and female.

2) Write a note on male and female reproductive organs.

3) Explain the role of hormones in female reproductive system.

4) Explain the importance of menarche and its role in reproductive process.

5) Examine the relevance of menopause in reproductive process.