UNIT - I

CHAPTER 2

Human Reproduction

Chapter Outline

Learning Objectives

- *Creates an awareness towards a healthy reproductive life in adolescents.*
- *Understands the structure of the male and female reproductive systems.*
- *Explains the functions of the structures associated with the male and female reproductive system.*
- *Compares the process of spermatogenesis and oogenesis.*
- *Discusses the changes in a female body during and after fertilisation.*
- *Appraises the role of hormones in the process of reproduction.*
- *Understands the events in pregnancy and foetal development.*

5W912W

In every child who is born, the potentiality of the human race is born again

- James Agee

Every organ system in the human body works continuously to maintain homeostasis for the survival of the individual. The human reproductive system is essential for the survival of the species. An individual may live a long healthy life without producing an offspring, but reproduction is inevitable for the existence of a species.

The reproductive system has four main functions namely,

- to produce the gametes namely sperms and ova
- to transport and sustain these gametes
- to nurture the developing offspring
- to produce hormones

The major reproductive events in human beings are as follows:

- **Gametogenesis:** Formation of gametes by spermatogenesis and oogenesis.
- **Insemination:** Transfer of sperms by the male into the female genital tract.
- **Fertilisation:** Fusion of male and female gametes to form zygote, called fertilisation.
- **Cleavage:** Rapid mitotic divisions of the zygote which convert the single celled

zygote into a multicellular structure called blastocyst.

- **Implantation:** Attachment of blastocyst to the uterine wall.
- **Placentation:** Formation of placenta which is the intimate connection between foetus and uterine wall of the mother for exchange of nutrients.
- **Gastrulation:** Process by which blastocyst is changed into a gastrula with three primary germ layers
- **Organogenesis:** Formation of specific tissues, organs and organ systems from three germ layers.
- **Parturition:** Expulsion of the foetus from the mother's womb.

These functions are carried out by the primary and accessory reproductive organs. The primary reproductive organs namely the ovary and testis are responsible for producing the ova and sperms respectively. Hormones secreted by the pituitary gland and the gonads help in the development of the secondary sexual characteristics, maturation of the reproductive system and regulation of normal functioning of the reproductive system. The accessory organs help in transport and to sustain the gametes and to nurture the developing offspring.

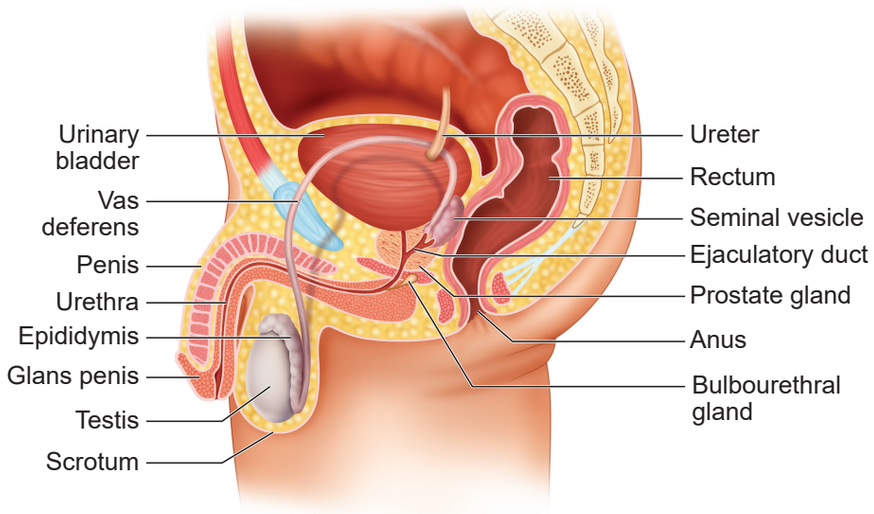


Fig. 2.1 Male reproductive system

2.1 Human reproductive system

The male reproductive system comprises of a pair of testes, accessory ducts, glands and external genitalia (**Fig. 2.1**).

Testes are the primary male sex organs. They are a pair of ovoid bodies lying in the scrotum (**Fig.2.2 a**). The scrotum is a sac of skin that hangs outside the abdominal cavity. Since viable sperms cannot be produced at normal body temperature, the scrotum is placed outside the abdominal cavity to provide a temperature 2-3°C lower than the normal internal body temperature. Thus, the scrotum acts as a **thermoregulator** for spermatogenesis.

Each testis is covered by an outermost fibrous **tunica albuginea** and is divided by septa into about **200 - 250 lobules** each containing 2-4 highly coiled testicular tubules or seminiferous tubules. These highly convoluted tubules which form 80 percent of the testicular substance are the sites for sperm production.

The stratified epithelium of the seminiferous tubule is made of two types of cells namely sertoli cells or nurse cells and spermatogonic cells or male germ cells. **Sertoli cells** are elongated and pyramidal and provide nourishment to the sperms till maturation. They also secrete **inhibin**, a hormone which is involved in the negative feedback control of sperm production. Spermatogonic cells divide meiotically and differentiate to produce spermatozoa.

Interstitial cells or Leydig cells are embedded in the soft connective tissue surrounding the seminiferous tubules. These cells are endocrine in nature and secrete

CRYPTORCHISM The failure of one or both testes to descend down into the scrotal sacs is known as cryptorchism (crypto – hidden + orchis – testicle). It occurs in 1 – 3 percent of new born males. A surgical correction at a young age can rectify the defect, else these individuals may become sterile and are unable to produce viable sperms.

androgens namely the testosterone hormone which initiates the process of spermatogenesis. These cells are endocrine in nature and are characteristic features of the testes of mammals. Other immunologically competent cells are also present.

The accessory ducts associated with the male reproductive system include **rete testis, vasa efferentia, epididymis and vas deferens (Fig. 2.2 b)**. The seminiferous tubules of each lobule converge to form a tubulus rectus that conveys the sperms into the rete testis. The rete testis is a tubular network on the posterior side of the testis. The sperms leave the rete testis and enter the epididymis through the vasa efferentia. The epididymis is a single highly coiled tube that temporarily stores the spermatozoa and they undergo physiological maturation and acquire increased motility and fertilizing capacity. The epididymis leads to the vas deferens and joins the duct of the seminal vesicle to form the ejaculatory duct which passes through the prostate and opens into the urethra. The urethra is the terminal portion of the male reproductive system and is used to convey both urine and semen at different times. It originates from the urinary bladder and extends through the penis by an external opening called urethral meatus.

The accessory glands of the male reproductive system include the paired **seminal vesicles** and **bulbourethral glands** also called **Cowper's gland** and a single **prostate gland**. The seminal vesicles secrete an alkaline fluid called seminal plasma containing fructose sugar, ascorbic acid, prostaglandins and a coagulating enzyme called

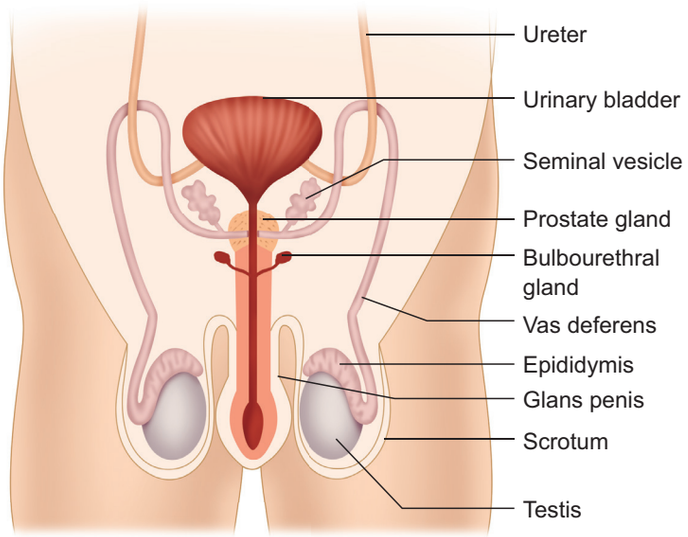


Fig. 2.2 (a) Diagrammatic view of the male reproductive system

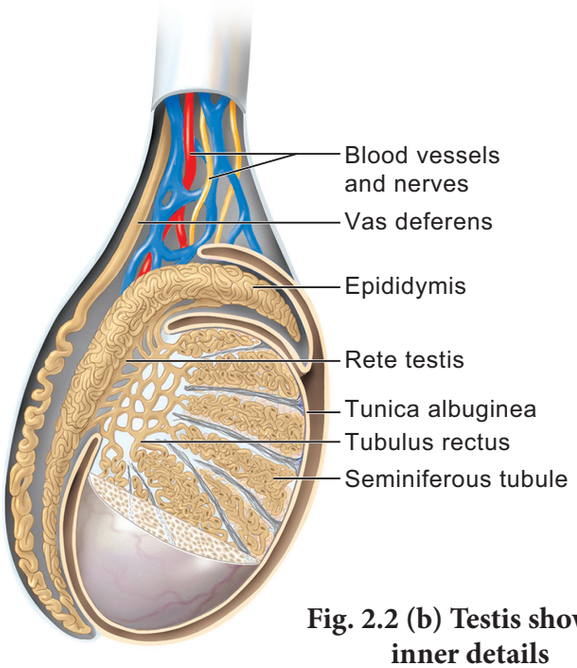


Fig. 2.2 (b) Testis showing inner details

vesiculase which enhances sperm motility. The bulbourethral glands are inferior to the prostate and their secretions also help in the lubrication of the penis. The prostate encircles the urethra and is just below the urinary bladder and secretes a slightly acidic fluid that contains citrate, several enzymes and prostate specific antigens. **Semen** or seminal fluid is a milky white fluid which contains sperms and the seminal plasma (secreted from the seminal vesicles, prostate gland and the bulbourethal glands). The seminal fluid acts as a transport medium, provides nutrients, contains chemicals that protect and activate the sperms and also facilitate their movement.

The penis is the male external genitalia functioning as a copulatory organ. It is made of a special tissue that helps in the erection of penis to facilitate insemination. The enlarged end of the penis called glans penis is covered by a loose fold of skin called foreskin or prepuce.

The female reproductive system is far more complex than the male because in addition to gamete formation, it has to nurture the developing foetus. The female reproductive system consists of a pair of ovaries along with a pair of oviducts, uterus, cervix, vagina and the external genitalia located in the pelvic region **(Fig. 2.3 a)**. These parts along with the mammary glands are integrated structurally and functionally to support the process of ovulation, fertilisation, pregnancy, child birth and child care.

Ovaries are the primary female sex organs that produce the female gamete, ovum. The ovaries are located one on each side of the lower abdomen. The ovary is an elliptical structure about 2-4 cm long. Each ovary is covered by a thin cuboidal epithelium called the germinal epithelium which encloses the **ovarian stroma**. The stroma is differentiated as the outer cortex and inner medulla. Below the germinal epithelium is a dense connective tissue, the **tunica albuginea**. The cortex appears dense and granular due to the presence of ovarian follicles in various stages of development. The medulla is a loose connective tissue with abundant blood vessels, lymphatic vessels and nerve fibres. The ovary remains attached to the pelvic wall and the uterus by an ovarian ligament called **mesovarium**.

The fallopian tubes (uterine tubes or oviducts), uterus and vagina constitute the female accessory organs **(Fig. 2.3 b)**. Each fallopian tube extends from the periphery of each ovary to the uterus. The proximal part of the fallopian tube bears a funnel shaped **infundibulum**. The edges of the infundibulum have many finger like projections called **fimbriae** which help in collection of the ovum after ovulation.

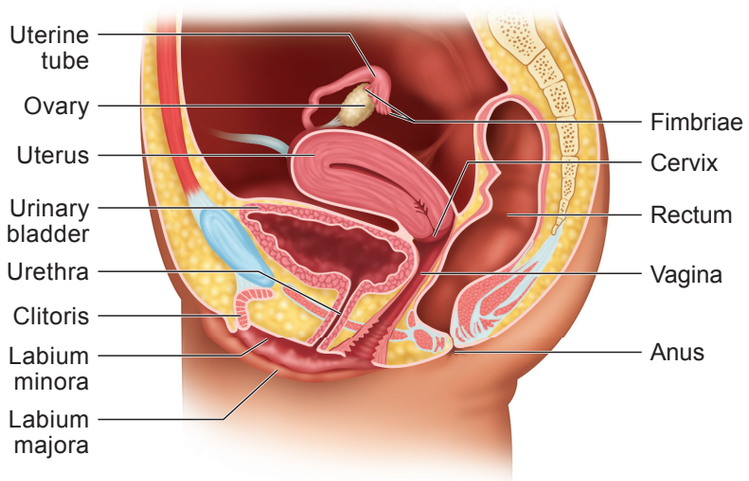


Fig. 2.3 (a) Female pelvis showing reproductive system

Female uterus contains one of the strongest muscles of the human body.

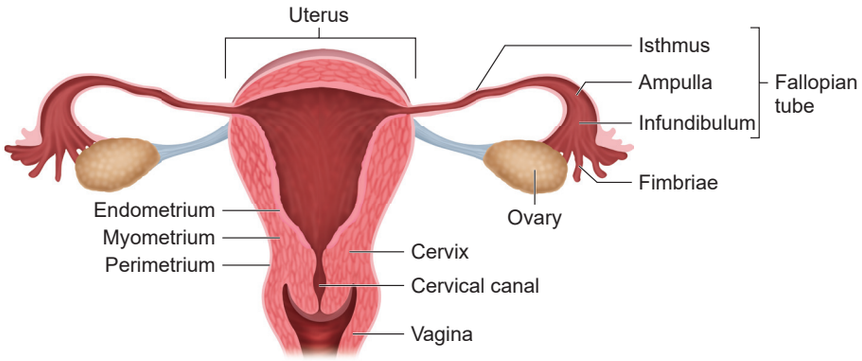


Fig. 2.3 (b) Diagrammatic view of female reproductive system

The infundibulum leads to a wider central portion called **ampulla**. The last part of the oviduct is the isthmus which is short and thick walled connecting the ampulla and infundibulum to the uterus.

The uterus or womb is a hollow, thick-walled, muscular, highly vascular and inverted pear shaped structure lying in the pelvic cavity between the urinary bladder and rectum. The major portion of the uterus is the body and the rounded region superior to it, is the **fundus**. The uterus opens into the vagina through a narrow **cervix**. The cavity of the cervix called the cervical canal communicates with the vagina through the external orifice and with the uterus through the internal orifice. The cervical canal along with vagina forms the birth canal.

The wall of the uterus has three layers of tissues. The outermost thin membranous serous layer called the **perimetrium**, the middle thick muscular layer called **myometrium** and the inner glandular layer called **endometrium**. The endometrium undergoes cyclic changes during the menstrual cycle while myometrium exhibits strong contractions during parturition.

Vagina is a large fibromuscular tube that extends from the cervix to the exterior. It is the female organ of copulation. The female reproductive structures that lie external to the vagina are called as the external genitalia or vulva comprising of **labia majora, labia minora, hymen and clitoris**.

The **Bartholin's glands** (also called greater vestibular glands) are located posterior to the left and right of the opening of the vagina. They secrete mucus to lubricate the vagina and are homologous to the bulbourethral glands of the male. The **Skene's glands** are located on the anterior wall of the vagina and around the lower end of the urethra. They secrete a lubricating fluid and are homologous to the prostate gland of the males.

The external opening of the vagina is partially closed by a thin ring of tissue called the hymen. The hymen is often torn during the first coitus (physical union). However in some women it remains intact. It can be stretched or torn due to a sudden fall or jolt and also during strenuous physical activities such as cycling, horseback riding, etc., and therefore cannot be considered as an indicator of a woman's virginity.

The **mammary glands** are modified sweat glands present in both sexes. It is rudimentary in the males and functional in the females. A pair of mammary glands is located in the thoracic region. It contains glandular tissue and variable quantities of fat with a median nipple surrounded by a pigmented area called the **areola**. Several sebaceous glands called the areolar glands are found on the surface and they reduce cracking of the skin of the nipple. Internally each mammary gland consists of 2-25 lobes, separated by fat and connective tissues **(Fig. 2.4).** Each lobe is made up of lobules which contain **acini or alveoli** lined by epithelial cells. Cells of the alveoli secrete milk. The alveoli open into **mammary tubules**. The tubules of each lobe join to form

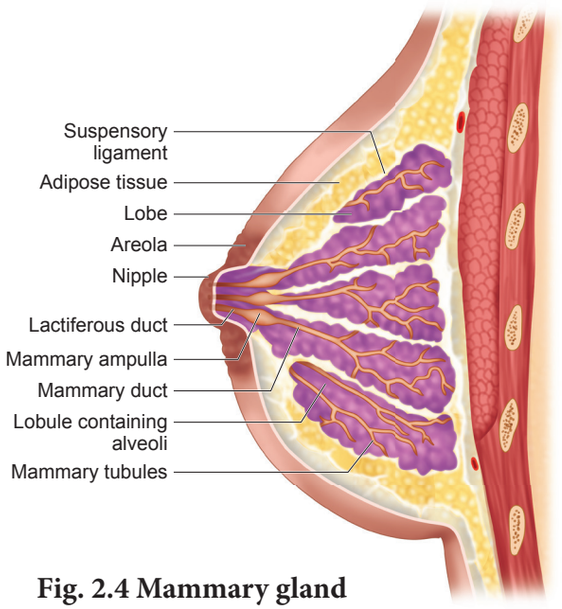


Fig. 2.4 Mammary gland

a **mammary duct**. Several mammary ducts join to form a wider **mammary ampulla** which is connected to the **lactiferous duct** in the nipple. Under the nipple, each lactiferous duct expands to form the **lactiferous sinus** which serves as a reservoir of milk. Each lactiferous duct opens separately by a minute pore on the surface of the nipple.

Normal development of the breast begins at puberty and progresses with changes during each menstrual cycle. In non-pregnant women, the glandular structure is largely underdeveloped and the breast size is largely due to amount of fat deposits. The size of the breast does not have an influence on the efficiency of lactation.

2.2 Gametogenesis

Gametogenesis is the process of formation of gametes i.e., sperms and ovary from the primary sex organs in all sexually reproducing organisms. Meiosis plays the most significant role in the process of gametogenesis **(Fig.2.5)**.

Spermatogenesis

Spermatogenesis is the sequence of events in the seminiferous tubules of the testes that produce the male gametes, the sperms. During development, the primordial germ cells migrate into the testes and become immature germ cells called sperm mother cells or spermatogonia in the inner surfaces of the seminiferous tubules **(Fig. 2.6 a)**. The spermatogonia begin to undergo mitotic division at puberty and continue throughout life.

In the first stage of spermatogenesis, the spermatogonia migrate among sertoli cells towards the central lumen of the seminiferous tubule and become modified and enlarged to form primary spermatocytes which are diploid with 23 pairs i.e., 46 chromosomes.

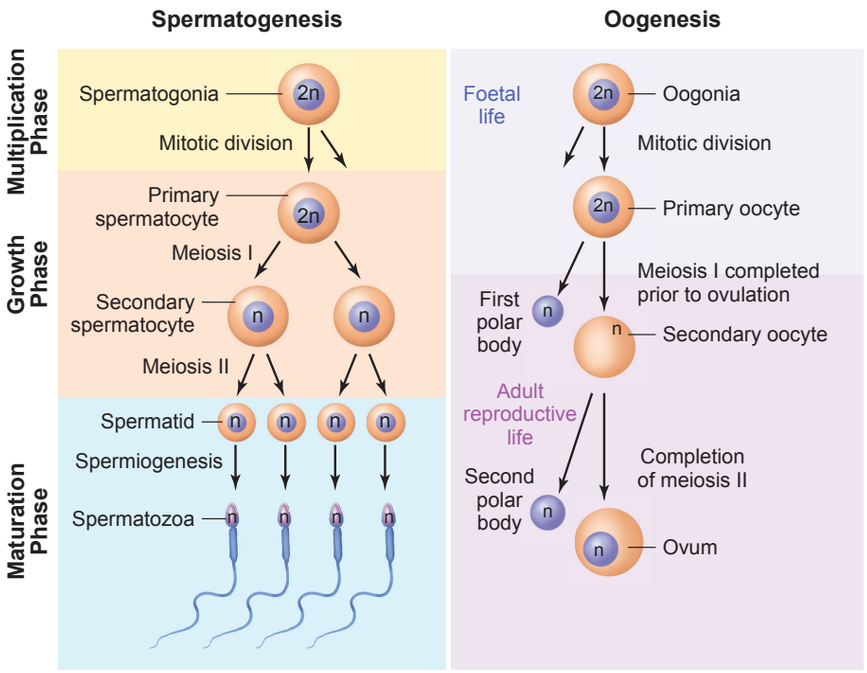


Fig. 2.5 Gametogenesis

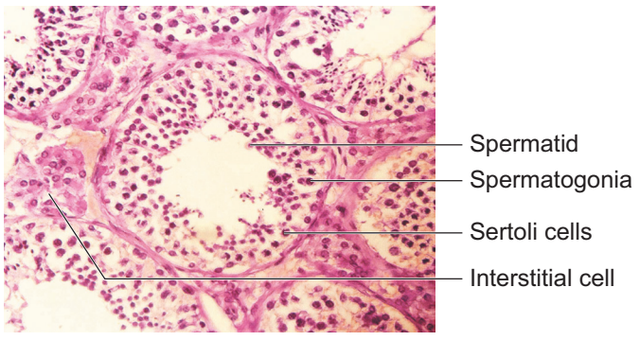


Fig. 2.6 (a) Cross sectional view of seminiferous tubule

Some of the primary spermatocytes undergo first meiotic division to form two secondary spermatocytes which are haploid with 23 chromosomes each. The secondary spermatocytes undergo second meiotic division to produce four haploid spermatids. The spermatids are transformed into mature **spermatozoa (sperms)** by the process called **spermiogenesis**. Sperms are finally released into the cavity of seminiferous tubules by a process called **spermiation**. The whole process of spermatogenesis takes about 64 days. At any given time, different regions of the seminiferous tubules contain spermatocytes in different stages of development **(Fig. 2.6 b)**. The sperm production remains nearly constant at a rate of about 200 million sperms per day.

Spermatogenesis starts at the age of puberty and is initiated due to the increase in the release of **Gonadotropin Releasing Hormone (GnRH)** by the hypothalamus. GnRH acts on the anterior pituitary gland and stimulates the secretion of two gonadotropins namely **Follicle Stimulating Hormone (FSH)** and **Lutenizing Hormone (LH)**. FSH stimulates testicular growth and enhances the production of **Androgen Binding Protein (ABP)** by the sertoli cells and helps in the process of spermiogenesis. LH acts on the Leydig cells and stimulates the synthesis of **testosterone** which in turn stimulates the process of spermatogenesis.

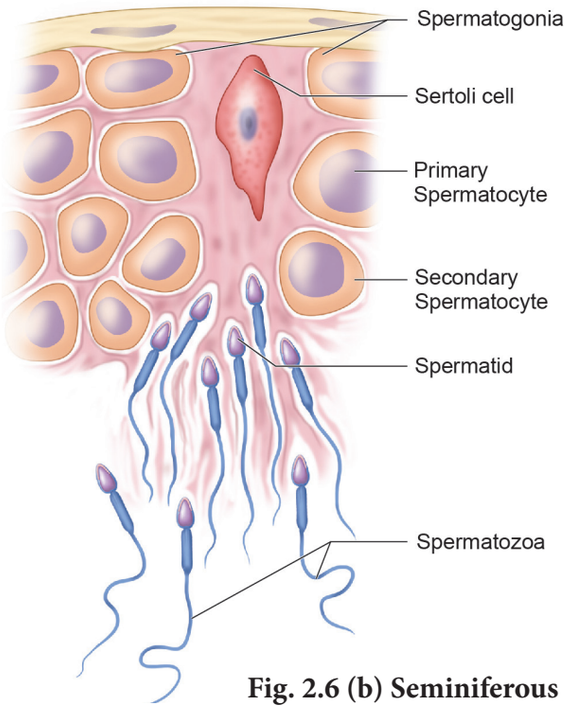


Fig. 2.6 (b) Seminiferous tubules (Enlarged)

Structure of human spermatozoan

The human sperm is a microscopic, flagellated and motile gamete (Fig. 2.7). The whole body of the sperm is enveloped by plasma membrane and is composed of a head, neck and a tail. The head comprises of two parts namely acrosome and nucleus. **Acrosome** is a small cap like pointed structure present at the tip of the nucleus and is formed mainly from the Golgi body of the spermatid. It contains **hyaluronidase**, a proteolytic enzyme, popularly known as sperm lysin which helps to penetrate the ovum during fertilisation. The nucleus is flat and oval. The neck is very short and is present between the head and the middle piece. It contains the proximal centriole towards the nucleus which plays a role in the first division of the zygote and the distal centriole gives rise to the axial filament of the sperm. The middle piece possesses mitochondria spirally twisted around the axial filament called **mitochondrial spiral or nebenkern**. It produces energy in the form of ATP molecules for the movement of sperms. The

tail is the longest part of the sperm and is slender and tapering. It is formed of a central axial filament or **axoneme** and an outer protoplasmic sheath. The lashing movements of the tail push the sperm forward. The human male ejaculates about 200 to 300 million sperms during coitus. It is estimated that around 60 percent of sperms must have normal shape of which at least 40 per cent must show vigorous motility for normal fertility.

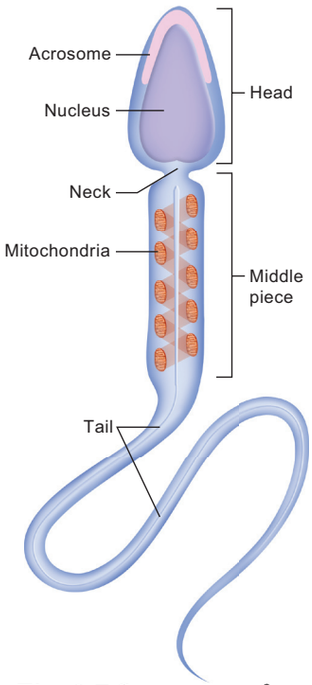


Fig. 2.7 Structure of human sperm

The sperm is the smallest human cell and the ovum or egg is the largest human cell.

Oogenesis

Oogenesis is the process of development of the female gamete or ovum or egg in the ovaries. During foetal development, certain cells in the germinal epithelium of the foetal ovary divide by mitosis and produce millions of **egg mother cells or oogonia**. No more oogonia are formed or added after birth. The oogonial cells start dividing and enter into Prophase I of meiotic division I to form the **primary oocytes** which are temporarily arrested at this stage. The primary oocytes then get surrounded by a single layer of granulosa cells to form the primordial or **primary follicles (Fig. 2.8 a)**. A large number of follicles degenerate during the period from birth to puberty, so at puberty only 60,000 to 80,000 follicles are left in each ovary.

Out of the million eggs women possess during birth, only about 300 to 400 will ovulate before menopause.

On the other hand, males produce more than 500 billion sperms in their life time.

The primary follicle gets surrounded by many layers of granulosa cells and a new theca layer to form the **secondary follicle**. A fluid filled space, the antrum develops in the follicle and gets transformed into a **tertiary follicle**. The theca layer gets organized into an inner theca interna and an outer theca externa. At this time, the primary oocyte within the tertiary follicle grows in size and completes its first meiotic division and forms the **secondary oocyte**. It is an unequal division resulting in the formation of a large haploid secondary oocyte and a first polar body. The first polar body disintegrates. During fertilisation, the secondary oocyte undergoes second meiotic division and produces a large cell, the **ovum** and a second polar body. The second polar body also degenerates. The tertiary follicle eventually becomes a mature follicle or **Graafian follicle**. If fertilisation does not take place, second meiotic division is never completed and the egg disintegrates. At the end of gametogenesis in females, each primary oocyte gives rise to only one haploid ovum.

Structure of ovum

Human ovum is **non-cleidoic, alecithal** and microscopic in nature. (Fig. 2.8 (b)). Its cytoplasm called **ooplasm** contains a large nucleus called the germinal vesicle. The ovum is surrounded by three coverings namely an inner thin transparent **vitelline membrane**, middle thick **zona pellucida** and outer thick coat of follicular cells called **corona radiata**. Between the vitelline membrane and zona pellucida is a narrow perivitelline space.

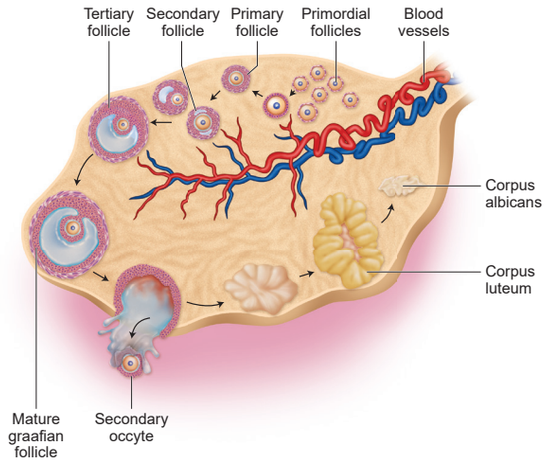


Fig. 2.8 (a) Sectional view of the ovary

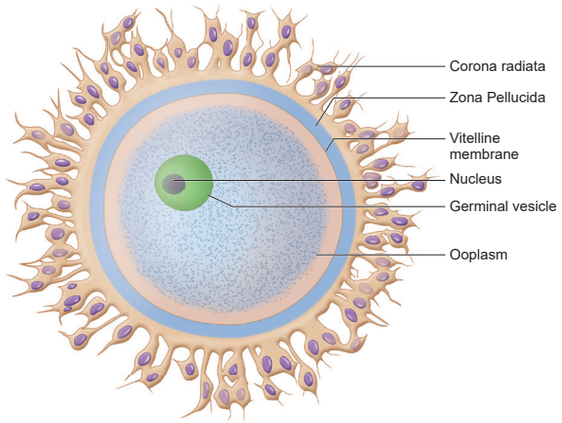


Fig. 2.8 (b) Diagrammatic view of the human ovum

2.3 Menstrual cycle

The **menstrual or ovarian cycle** occurs approximately once in every 28/29 days during the reproductive life of the female from **menarche** (puberty) to **menopause** except during pregnancy. The cycle of events starting from one menstrual period till the next one is called the menstrual cycle during which cyclic changes occurs in the endometrium every month. Cyclic menstruation is an indicator of normal reproductive phase **(Fig. 2.9)**.

Menstrual cycle comprises of the following phases

1. Menstrual phase
2. Follicular or proliferative phase
3. Ovulatory phase
4. Luteal or secretory phase

1. Menstrual phase

The cycle starts with the menstrual phase when menstrual flow occurs and lasts for 3-5 days. Menstrual flow is due to the breakdown of endometrial lining of the uterus, and its blood vessels due to decline in the level of progesterone and oestrogen. Menstruation occurs only if the released ovum is not fertilized. Absence of menstruation may be an indicator of pregnancy. However it could also be due to stress, hormonal disorder and anaemia.

2. Follicular or proliferative phase

The follicular phase extends from the 5th day of the cycle until the time of ovulation. During this phase, the primary follicle in the ovary grows to become a fully mature Graafian follicle and simultaneously, the endometrium regenerates through proliferation. These changes in the ovary and the uterus are induced by the secretion of gonadotropins like FSH and LH, which increase gradually during the follicular phase. It stimulates follicular development and secretion of **oestrogen** by the follicle cells.

3. Ovulatory phase

Both LH and FSH attain peak level in the middle of the cycle (about the 14th day). Maximum secretion of LH during the mid cycle called **LH surge** induces the rupture of the Graafian follicle and the release of the ovum (secondary oocyte) from the ovary wall into the peritoneal cavity. This process is called as **ovulation**.

4. Luteal or secretory phase

During luteal phase, the remaining part of the Graafian follicle is transformed into a transitory endocrine gland called corpus luteum. The corpus luteum secretes large amount of progesterone which is essential for the maintenance of the endometrium. If fertilisation takes place, it paves way for

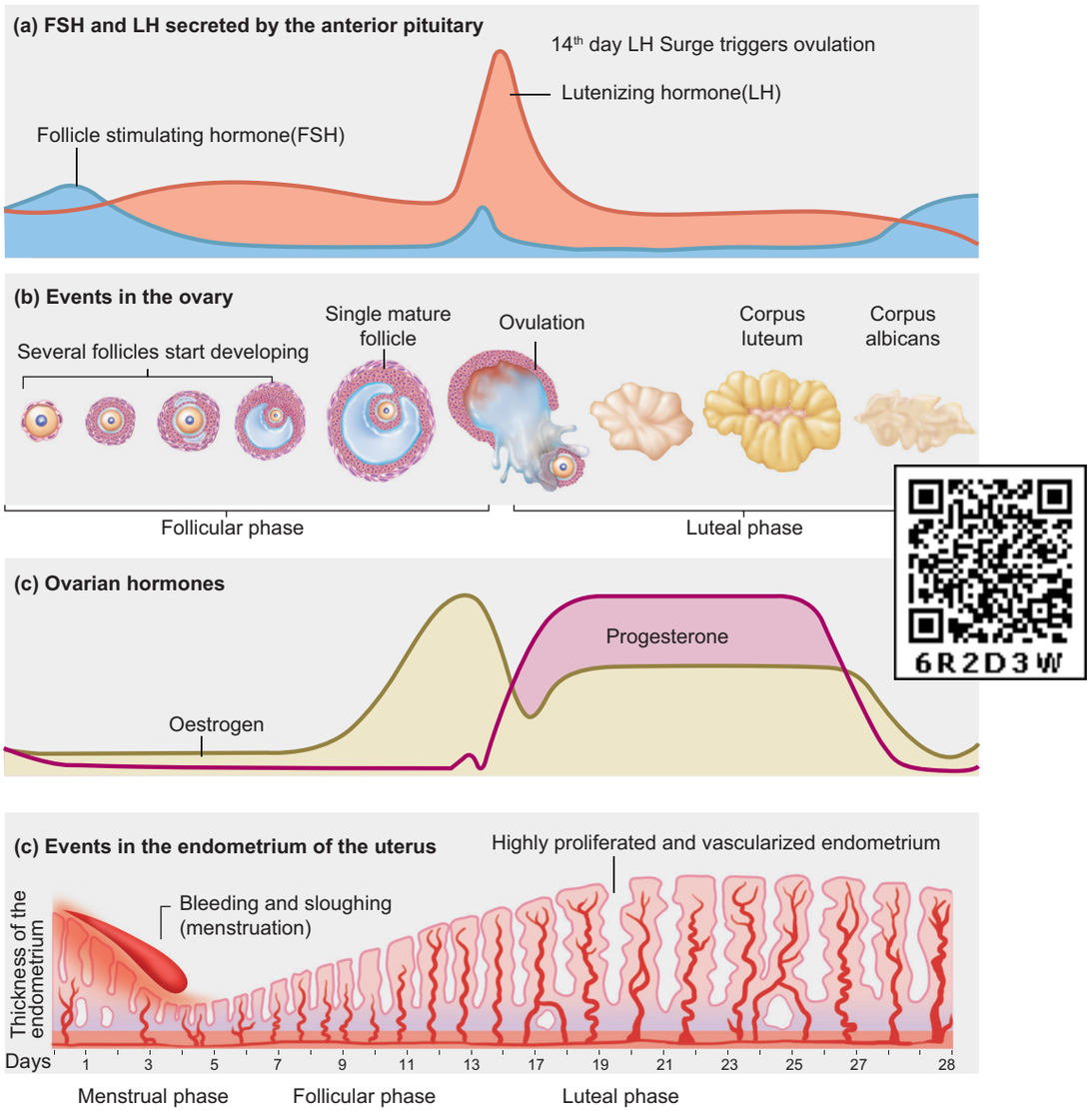


Fig. 2.9 Different phases of the menstrual cycle

the implantation of the fertilized ovum. The uterine wall secretes nutritious fluid in the uterus for the foetus. So, this phase is also called as **secretory phase.** During pregnancy all events of menstrual cycle stop and there is no menstruation.

In the absence of fertilisation, the corpus luteum degenerates completely and leaves a scar tissue called **corpus albicans**. It also initiates the disintegration of the endometrium leading to menstruation, marking the next cycle.

POLY CYSTIC OVARY SYNDROME (PCOS)

PCOS is a complex endocrine system disorder that affects women in their reproductive years. Polycystic means 'many cysts'. It refers to many partially formed follicles on the ovaries, which contain an egg each. But they do not grow to maturity or produce eggs that can be fertilized. Women with PCOS may experience irregular menstrual cycles, increased androgen levels, excessive facial or body hair growth (**hirsutism**), acne, obesity, reduced fertility and increased risk of diabetes. Treatment for PCOS includes a healthy lifestyle, weight loss and targeted hormone therapy.

2.4 Menstrual disorders

Absence of menstruation is called **amenorrhoea**. If menarche does not appear till the age of 18, it is called **primary amenorrhoea**. Absence of menstruation for over three consecutive months is **secondary amenorrhoea**.

Polymenorrhoea is a term used to describe a menstrual cycle that is shorter than 21 days. It may be due to hyperactivity of the anterior pituitary gland causing frequent ovulation, psychological disturbances and malnutrition. Chronic pelvic inflammation by certain sexually transmitted diseases (STD) such as **chlamydiasis or gonorrhoea** can cause inflammation in the uterus causing polymenorrhoea.

Pain associated with menstruation is called **dysmenorrhoea**. It is the most commonly reported menstrual disorder. There are two types of dysmenorrhoea viz primary and secondary dysmenorrhoea. **Primary dysmenorrhoea** is pain or cramps during menstrual period and is caused by secretions of prostaglandin in the uterus. **Secondary dysmenorrhoea** is caused by a disorder in the reproductive system like endometriosis or uterine fibroids.

Heavy and prolonged menstrual period that disrupts a woman's normal activities is referred to as **menorrhagia**. Menorrhagia may be due to hormonal imbalance, ovarian dysfunction, uterine fibroids and may also be due to cancer of the ovary, uterus or cervix.

Oligomenorrhoea is a condition with infrequent menstrual periods. It occurs in women of childbearing age. Some variation in menstruation is normal, but a woman who regularly goes more than 35 days without menstruating may be diagnosed with **oligomenorrhoea**.

Menstrual hygiene

Menstrual hygiene is vital for good health, well-being, dignity, empowerment and productivity of women. The impact of poor menstrual hygiene on girls is increased stress levels, fear and embarrassment during menstruation. This can keep girls inactive during such periods leading to absenteeism from school.

Clean and safe **absorbable clothing materials, sanitary napkins, pads, tampons and menstrual cups** have been identified as materials used to manage menstruation. Changing sanitary material 4-5 hours as per the requirement, provides comfort, cleanliness and protection from infections. It also helps in enhancing the quality of life of women during this period. Used sanitary napkins should be wrapped in paper and disposed. It should not be thrown in open areas or drain pipe of toilets. Flushing of sanitary napkins in the drain pipes causes choking of the drainage line leading to water pollution.

Disposal of Napkins

The ecofriendly way to dispose menstrual waste scientifically and hygienically is to destroy the sanitary napkins using incinerators. Measures are being taken to install incinerators and napkin vending machines in washrooms of schools , colleges and public facilities.

Menopause

Menopause is the phase in a women's life when ovulation and menstruation stops. The average age of menopause is 45-50 years. It indicates the permanent cessation of the primary functions of the ovaries.

2.5 Fertilisation and implantation

Fertilisation occurs when a haploid sperm fuses with a haploid ovum to form a fertilized egg or diploid zygote.

The sperms deposited in the female reproductive tract undergo **capacitation**, which

is a biochemical event that enables the sperm to penetrate and fertilise the egg. Fertilisation occurs only if the ovum and sperms are transported simultaneously to the ampullary isthmic junction of the fallopian tube.

Before a sperm can enter the egg, it must penetrate the multiple layers of granulosa (follicular) cells which are around the ovum forming the **corona radiata (Fig. 2.10).** The follicular cells are held together by an adhesive cementing substance called hyaluronic acid. The acrosomal membrane disintegrates releasing the proteolytic enzyme, **hyaluronidase** during sperm entry through the corona radiata and zona pellucida. This is called **acrosomal reaction**. Once fertilisation is accomplished, cortical granules from the cytoplasm of the ovum form a barrier called the **fertilisation membrane** around the ovum preventing further penetration of other sperms. Thus **polyspermy** is prevented.

The first cleavage produces two identical cells called **blastomeres**. These produce 4 cells, then 8 and so on. After 72 hours of fertilisation, a loose collection of cells forms a berry shaped cluster of 16 or more cells called the **morula (Fig. 2.11)**.

Under the influence of progesterone, smooth muscles of the fallopian tube relax and the dividing embryo takes 4-5 days to move through the fallopian tube into the uterine cavity and finally gets implanted in the uterine wall. At this point the embryo consists of a fluid filled hollow ball of about 100 cells, called the **blastocyst**. The blastocyst is composed of a single layer of large flattened cells called **trophoblast** and a small cluster of 20-30 rounded cells called the **inner cell mass**. The inner cell mass of the blastocyst develops into the **embryo** and becomes embedded in the endometrium of the uterus. This process is called **implantation** and it results in pregnancy.

If the fertilised ovum is implanted outside the uterus it results in **ectopic pregnancy**. About 95 percent of ectopic pregnancies occur in the fallopian tube. The growth of the embryo may cause internal bleeding, infection and in some cases even death due to rupture of the fallopian tube.

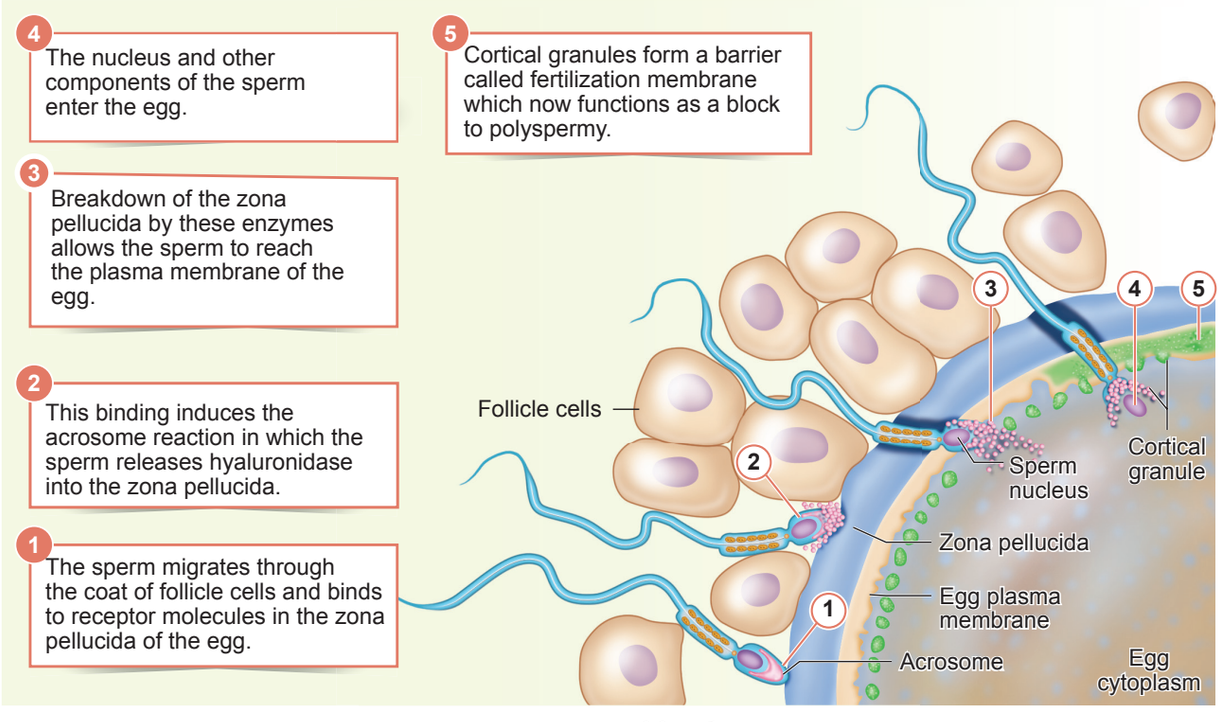


Fig. 2.10 Events of fertilisation

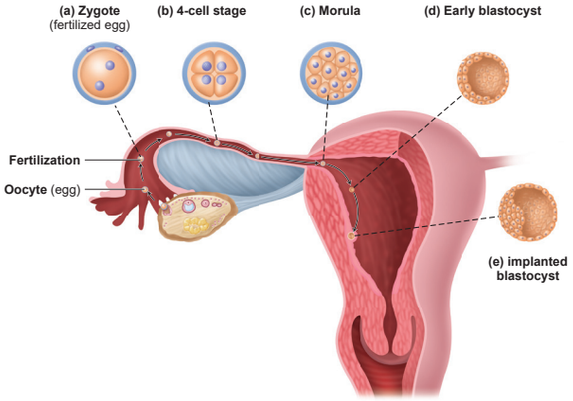


Fig. 2.11 From zygote to blastocyst : passage of growing embryo through the fallopian tube

Twins are two offsprings produced in the same pregnancy.

- Monozygotic (Identical) twins are produced when a single fertilised egg splits into two during the first cleavage. They are of the same sex, look alike and share the same genes.
- Dizygotic (Fraternal) twins are produced when two separate eggs are fertilised by two separate sperms. The twins may be of the same sex or different sex and are non-identical.
- Siamese (United) twins are the conjoined twins who are joined during birth.

2.6 Maintenance of pregnancy and embryonic development

The inner cell mass in the blastula is differentiated into **epiblast** and **hypoblast** immediately after implantation. The **hypoblast** is the embryonic endoderm and the **epiblast** is the ectoderm. The cells remaining in between the epiblast and the endoderm form the mesoderm. Thus the transformation of the blastocyst into a gastrula with the primary germ layers by the movement of the blastomeres is called **gastrulation**. Each germ layer gives rise to specific tissues, organs and organ systems during organogenesis.

The extra embryonic membranes namely the **amnion, yolk sac, allantois** and **chorion** protect the embryo from dessication, mechanical shock and help in the absorption of nutrients and exchange of gases **(Fig. 2.12)**. The amnion is a double layered translucent membrane filled with the amniotic fluid. It provides a buoyant environment to protect the developing embryo from injury, regulates the temperature of the foetus and provides a medium in which the foetus can move. The yolk sac forms a part of the gut and is the source of the earliest blood cells and blood vessels.

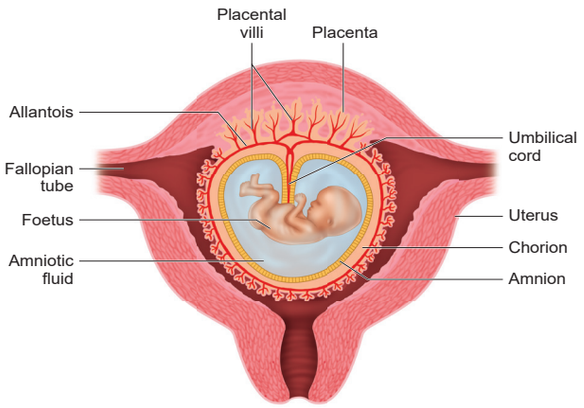


Fig. 2.12 Human foetus within the uterus

The allantois forms a small out pocketing of embryonic tissue at the caudal end of the yolk sac. It is the structural base for the umbilical cord that links the embryo to the placenta and ultimately it becomes part of the urinary bladder. The chorion is the outermost membrane which encloses the embryo and all other membranes and also helps in the formation of the placenta.

The trophoblast cells in the blastocyst send out several finger like projections called **chorionic villi** carrying foetal blood and are surrounded by sinuses that contain maternal blood. The chorionic villi and the uterine tissues form the disc-shaped placenta. **Placenta** is a temporary endocrine organ formed during pregnancy and it connects the foetus to the

uterine wall through the umbilical cord. It is the organ by which the nutritive, respiratory and excretory functions are fulfilled. The embryo's heart develops during the fourth week of pregnancy and circulates blood through the umbilical cord and placenta as well as through its own tissues.

The primary germ layers serve as the primitive tissues from which all body organs develop. The ectoderm gives rise to the central nervous system (brain and spinal cord), peripheral nervous system, epidermis and its derivatives and mammary glands. The connective tissue, cartilage and bone, muscles, organs of urinogenital system (kidney, ureter and gonads) arise from the mesoderm. The endodermal derivatives are **e**pithelium of gastrointestinal and respiratory tract, liver, pancreas, thyroid and parathyroids.

Human pregnancy lasts for about 280 days or 40 weeks and is called the **gestation period**. It can be divided for convenience into three trimesters of three months each. The **first trimester** is the main period of organogenesis, the body organs namely the heart, limbs, lungs, liver and external genital organs are well developed. By the end of the **second trimester**, the face is well formed with features, eyelids and eyelashes, eyes blink, body is covered with fine hair, muscle tissue develops and bones become harder. The foetus is fully developed and is ready for delivery by the end of nine months (**third trimester**).

During pregnancy, the placenta acts as a temporary endocrine gland and produces large quantities of **human Chorionic Gonadotropin (hCG), human Chorionic Somatomammotropin (hCS) or human Placental Lactogen (hPL), oestrogens and progesterone** which are essential for a normal pregnancy. A hormone called **relaxin** is also secreted during the later phase of pregnancy which helps in relaxation of the pelvic ligaments at the time of parturition. It should be noted that hCG, hPL and relaxin are produced only during pregnancy. In addition, during pregnancy the level of other hormones like oestrogen and progesterone, cortisol, prolactin, thyroxine, etc., is increased several folds in the maternal blood. These hormones are essential for supporting foetal growth.

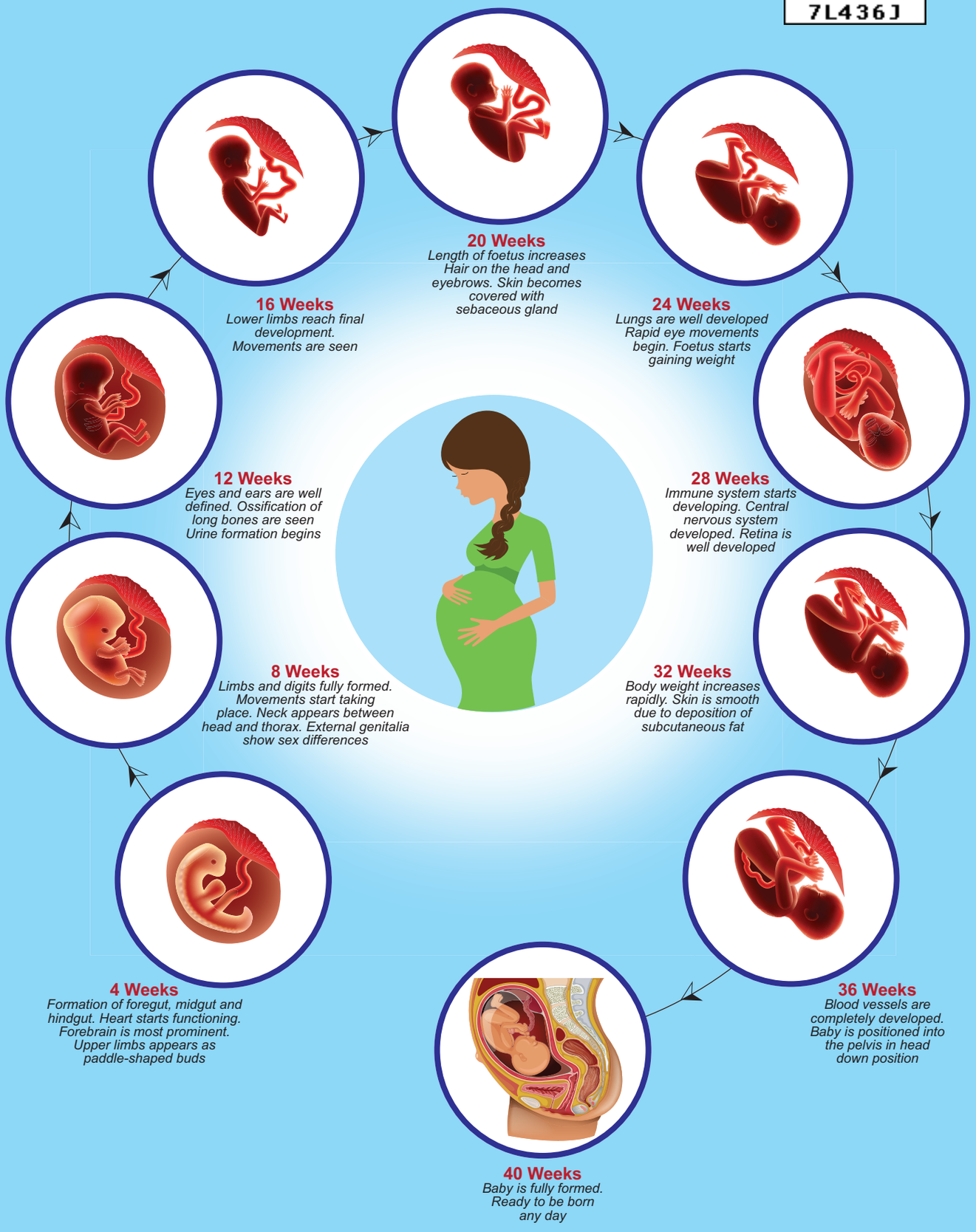
A female uterus is normally about 3 inches long and 2 inches wide but can expand 20 times during pregnancy.

2.7 Parturition and lactation

Parturition is the completion of pregnancy and giving birth to the baby. The series of events that expels the infant from the uterus is collectively called "labour". Throughout pregnancy the uterus undergoes periodic episodes of weak and strong contractions. These contractions called **Braxter-Hick's contractions** lead to false labour. As the pregnancy progresses, increase in the oestrogen concentration promotes uterine contractions. These uterine contractions facilitate moulding of the foetus and downward movement of the foetus. The descent of the foetus causes dilation of cervix of the uterus and vaginal canal resulting in a **neurohumoral reflex** called **Foetal ejection reflex** or **Ferguson reflex**. This initiates the secretion of oxytocin from the neurohypophysis which in turn brings about the powerful contraction of the uterine muscles and leads to the expulsion of the baby through the birth canal. This sequence of events is called as **parturition** or **childbirth**.

Relaxin is a hormone secreted by the placenta and also found in the corpus luteum. It promotes parturition by relaxing the pelvic joints and by dilatation of the cervix with continued powerful contractions. The amnion ruptures and the amniotic fluid flows out

STAGES OF FOETAL DEVELOPMENT



CAESAREAN When normal vaginal delivery is not possible due to factors like position of the baby and nature of the placenta, the baby is delivered through a surgical incision in the woman's abdomen and uterus. It is also termed as abdominal delivery or Caesarean Section or 'C' Section.

through the vagina, followed by the foetus. The placenta along with the remains of the umbilical cord called **"after birth"** is expelled out after delivery.

Lactation is the production of milk by mammary glands. The mammary glands show changes during every menstrual cycle, during pregnancy and lactation. Increased level of oestrogens, progesterone and **human Placental Lactogen (hPL)** towards the end of pregnancy stimulate the hypothalamus towards prolactin – releasing factors. The anterior pituitary responds by secreting **prolactin** which plays a major role in lactogenesis.

Oxytocin causes the "**Let-Down" reflex**- the actual ejection of milk from the alveoli of the mammary glands. During lactation, oxytocin also stimulates the recently emptied uterus to contract, helping it to return to pre - pregnancy size.

Colostrum

Colostrum, a nutrient rich fluid produced by the human female immediately after giving birth, is loaded with immune, growth and tissue repair factors. It acts as a natural antimicrobial agent to actively stimulate the maturation of the infant's immune system. No artificial feed can substitute the first milk, with all its natural benefits and therefore should be definitely fed to the baby after birth.

The mammary glands secrete a yellowish fluid called **colostrum** during the initial few days after parturition. It has less lactose than milk and almost no fat, but it contains more proteins, vitamin A and minerals. Colostrum is also rich in **IgA** antibodies. This helps to protect the infant's digestive tract against bacterial infection. Breast milk is the ideal food for infants as it contains all the constituents in suitable concentration and is easily digestible. It is fully sufficient till about 6 months of age and all infants must be breast fed by the mother to ensure the growth of a healthy baby.

Summary

Reproduction is a process which helps in the continuity and maintenance of a species. Human beings are sexually reproducing and viviparous. The reproductive events include gametogenesis, insemination, Fertilisation, cleavage, implantation, placentation, gastrulation, organogenesis and parturition.

The female reproductive system consists of a pair of ovaries, a pair of oviducts, uterus, cervix, vagina and external genitalia. The male reproductive system consists of a pair of testes, a pair of duct system, accessory glands and external genitalia called penis.

The process of formation of gametes in the male is called spermatogenesis and in the female is called oogenesis. The reproductive cycle in females is called menstrual cycle and it is initiated at puberty. The ovum released during the menstrual cycle is fertilized by the sperm and the zygote is formed.

Zygote undergoes repeated mitotic division and the blastocyst is implanted on the walls of the uterus. It takes about 280 days or 40 weeks for the entire development of the human foetus and it is delivered out through the process of child birth or parturition. The new born baby is breast fed by the mother.

World Breast feeding week (WBW)
August 1st week

WBW is organized and promoted world wide by WABA (World Alliance for Breast feeding Action), WHO (World Health Organization) and UNICEF (United Nations International Children's Emergency Fund) to stress the importance of breast feeding during the first six months of baby's life and a supplemented breast feeding for two years in order to encourage new mothers for the healthy growth and development of their children, to guard them from lethal health problems and diseases including neonatal jaundice, pneumonia, cholera, etc., The Government of Tamil Nadu has also initiated various projects like Mother's Milk Bank, Feeding rooms in bus terminals and also organisizes awareness campaigns during the first week of August to highlight the importance of breast feeding to infants.

INTERESTING FACTS

1. Males are said to be **sterile** when they fail to produce viable sperms.
2. ***Azospermia*** refers to the failure of spermatogenesis.
3. Enlargement of prostate gland is called ***prostatitis*** and can lead to difficulty in urination.
4. Castration or surgical removal of testis is known as ***orchidectomy***
5. ***Spermarche*** is the first ejaculation of the semen.

CASE STUDY

Arunachalam Muruganantham
Inventor And Social Entrepreneur

Arunachalam Muruganantham is the man behind the world's first low cost sanitary napkin making machine. His mission was to provide sanitary napkins at minimal cost to poor women across the country, especially in rural areas. The journey began when he was shocked by the fact that women in India including his wife often used things such as old rags, leaves and even ash during menstruation. Approximately 70 percent of all reproductive diseases in India are caused by poor menstrual hygiene. 23 percent of girls drop out of schools once they attain puberty. He wished to make a social impact by creating more livelihoods and improving the menstrual hygiene of rural women.

Arunachalam initiated his research in 1999 and almost after 5 years, successfully created a low cost machine for the production of sanitary napkins. He presented his prototype to IIT, Madras for a national innovation competition in 2006 and out of 943 entries, his machine stood first. Arunachalam made 250 machines in 18 months and set out to states in Northern India namely Bihar, Madhya Pradesh, Rajasthan and Uttar Pradesh.

Arunachalam Muruganantham was named one of the Time Magazine's 100 most influential people in 2014. He was awarded the Padma Shri in 2016.

Evaluation

1. The mature sperms are stored in the
   a. Seminiferous tubules
   b.Vas deferens
   c. **Epididymis**
   d. Seminal vesicle

2. The male sex hormone testosterone is secreted from
   a. Sertoli cells b. **Leydig cell**
   c. Epididymis d. Prostate gland

3. The glandular accessory organ which produces the largest proportion of semen is
   a. **Seminal vesicle**
   b. Bulbourethral gland
   c. Prostate gland
   d. Mucous gland

4. The male homologue of the female clitoris is
   a. Scrotum b. **Penis**
   c. Urethra d.Testis

5. The site of embryo implantation is the
   a. **Uterus** b. Peritoneal cavity
   c. Vagina d. Fallopian tube

6. The foetal membrane that forms the basis of the umbilical cord is
   a. **Allantois** b. Amnion
   c. Chorion d. Yolk sac

7. The most important hormone in intiating and maintaining lactation after birth is
   a. Oestrogen b. FSH
   c. **Prolactin** d. Oxytocin

8. Mammalian egg is
   a. Mesolecithal and non cleidoic
   b. Microlecithal and non cleidoic
   c. **Alecithal and non cleidoic**
   d. Alecithal and cleidoic

9. The process which the sperm undergoes before penetrating the ovum is
   a. Spermiation
   b. Cortical reaction
   c. Spermiogenesis
   d. **Capacitation**

10. Painful menstruation is termed as
    a. **Dysmenorrhoea**
    b. Menorrhagia
    c. Amenorrhoea
    d. Oligomenorrhoea

11. The milk secreted by the mammary glands soon after child birth is called
    a. Mucous b. **Colostrum**
    c. Lactose d. Sucrose

12. Colostrum is rich in
    a. Ig E b. **Ig A**
    c. Ig D d. Ig M

13. The Androgen Binding Protein (ABP) is produced by
    a. Leydig cells b. Hypothalamus
    c. **Sertoli cells** d. Pituitary gland

14. Which one of the following menstrual irregularities is correctly matched?
    a. Menorrhagia - excessive menstruation
    b. **Amenorrhoea - absence of menstruation**
    c. Dysmenorrhoea - irregularity of menstruation
    d. Oligomenorrhoea - painful menstruation

15. Find the wrongly matched pair
    a. Bleeding phase - fall in oestrogen and progesterone
    b. Follicular phase - rise in oestrogen
    c. **Luteal phase - rise in FSH level**
    d. Ovulatory phase - LH surge

Answer the following type of questions

Assertion (A) and Reason (R)

a. A and R are true, R is the correct explanation of A
b. A and R are true, R is not the correct explanation of A

c. A is true, R is false
d. Both A and R are false

16. **A** – In human male, testes are extra abdominal and lie in scrotal sacs.
R – Scrotum acts as thermoregulator and keeps temperature lower by 2°C for normal sperm production .
(a) A and R are true, R is the correct explanation of A

17. **A** – Ovulation is the release of ovum from the Graafian follicle.
R – It occurs during the follicular phase of the menstrual cycle.
(c) A is true, R is false

18. **A** – Head of the sperm consists of acrosome and mitochondria.
R – Acrosome contains spiral rows of mitochondria.
(d) Both A and R are false

19. Mention the differences between spermiogenesis and spermatogenesis.

20. At what stage of development are the gametes formed in new born male and female?

21. Expand the acronyms

a. FSH b. LH c. hCG d. hPL

22. How is polyspermy avoided in humans?

23. What is colostrum? Write its significance.

24. Placenta is an endocrine tissue. Justify.

25. Draw a labeled sketch of a spermatozoan.

26. What is inhibin? State its functions.

27. Mention the importance of the position of the testes in humans.

28. What is the composition of semen?

29. Name the hormones produced from the placenta during pregnancy.

30. Define gametogenesis.

31. Describe the structure of the human ovum with a neat labelled diagram.

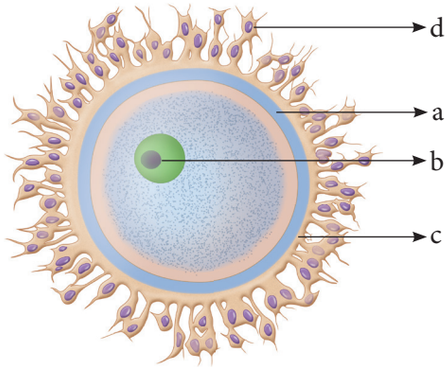
32. Give a schematic representation of spermatogenesis and oogenesis in humans.

33. Explain the various phases of the menstrual cycle.

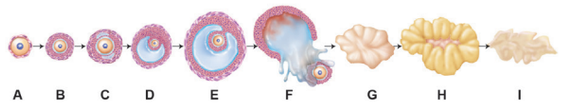
34. List the various menstrual disorders.

35. Explain the role of oxytocin and relaxin in parturition and lactation.

36. Identify the given image and label its parts marked as a, b, c and d



37. The following is the illustration of the sequence of ovarian events (a-i) in a human female.



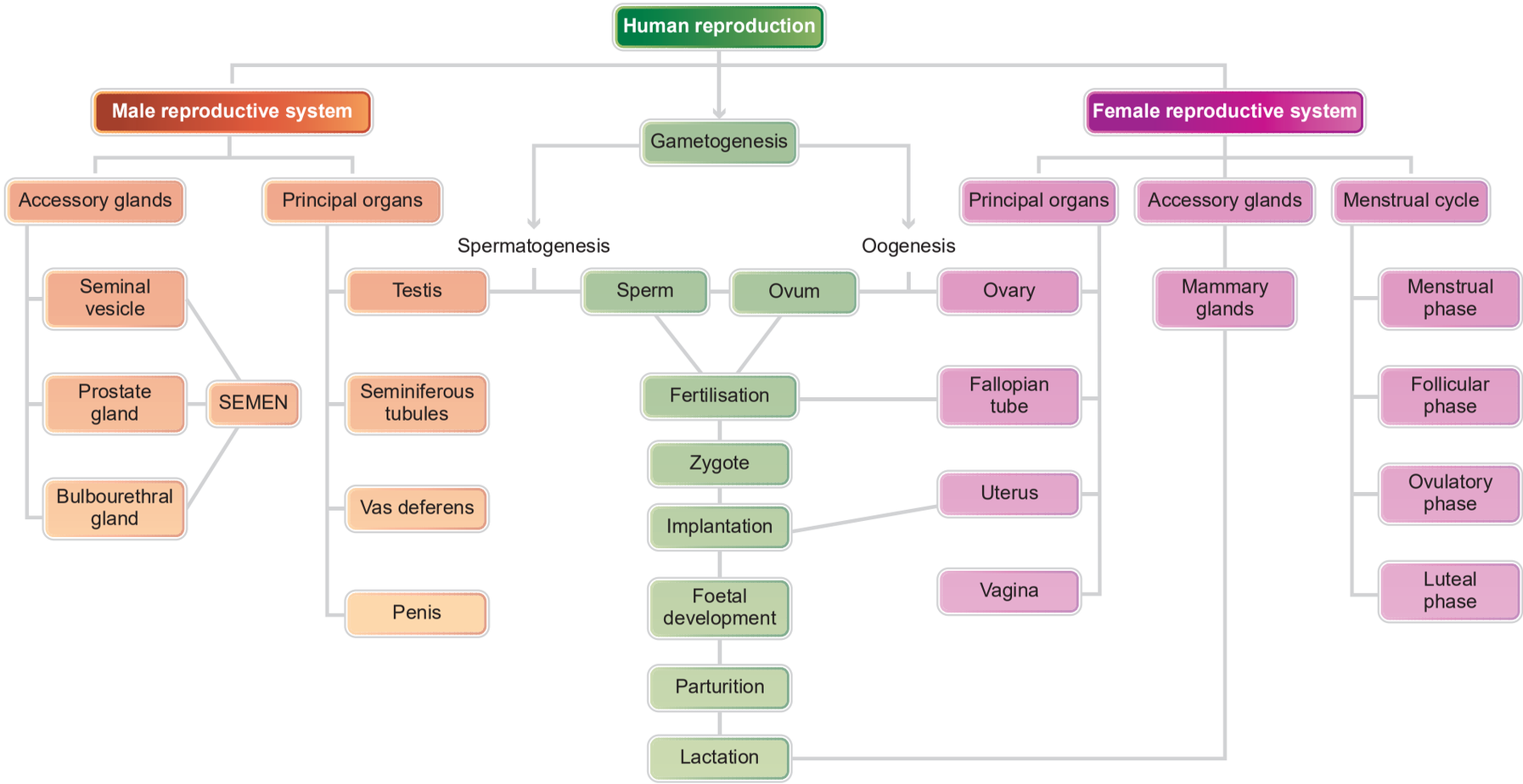
a) Identify the figure that illustrates ovulation and mention the stage of oogenesis it represents.

b) Name the ovarian hormone and the pituitary hormone that have caused the above-mentioned events.

c) Explain the changes that occurs in the uterus simultaneously in anticipation.

d) Write the difference between C and H.

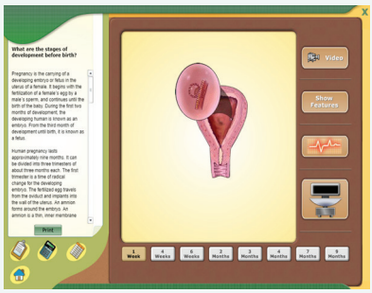
Concept Map



ICT CORNER

HUMAN REPRODUCTION

Baby's Journey to the world.



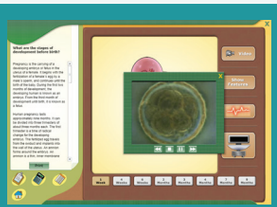
Procedure:

Step 1: Use the **URL** or scan the **QR** Code to launch the **"Stages of Development before Birth"** activity page.

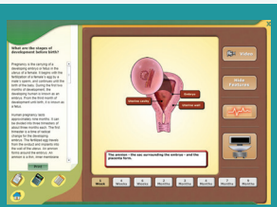
Step 2: **On the right of the window, Click "Video" and view the development of embryo during that particular stage.**

Step 3: Click "Show Features" to know the parts. Click **"Heartbeat-Symbol"** to hear the heartbeat of the embryo at that particular stage. Click **"Weighing Machine"** placed below to know the weight of the offspring at that stage.

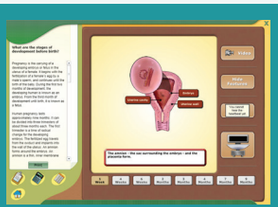
Step 4: Repeat the above steps with the different weeks by clicking the respective week tabs placed below.



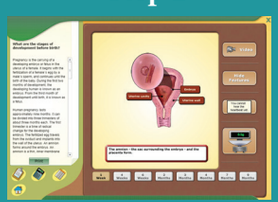
Step 1



Step 2



Step 3



Step 4

HUMAN REPRODUCTION URL:

http://www.glencoe.com/sites/common_assets/science/virtual_labs/LS26/LS26.html

*Pictures are indicative only

*Allow flash player

B267_12_Z00_EM