2 Reproduction in Lower and Higher Animals

Can you recall?

1. Enlist the various life processes. Name the life process which is responsible for continuation of the human race.
2. What are the common methods of reproduction in the unicellular organisms like *Euglena*, *Amoeba* and *Paramoecium*?
3. What type of asexual reproduction occurs in *Hydra*?
4. What are the different methods of reproduction in animals?

We know that reproduction is one of the major life processes of any living organism. It helps in maintaining the continuity of the species. **Reproduction** is defined as the biological process of formation of new life forms from pre-existing similar life. It thus becomes a vital process which enables the species to survive over a long period, even though the individuals or organisms live naturally for a limited period of time i.e. their life span. In this chapter, we will learn about the various methods of reproduction in animals the human reproductive system, gametogenesis and fertilization, early embryology, parturition and reproductive health.

Reproduction in animals occurs mainly by two methods i.e. asexual and sexual.

2.1 Asexual Reproduction in animals :

It is a common method among lower animals. It does not involve meiosis nor the gamete formation and fusion. The formation of progeny is by a single parent only and does not involve both the sexes, so it is called asexual reproduction. The progeny or daughter cells are genetically identical to the single parent and are also referred to as **clones**. The lower animals reproduce asexually by gemmule formation and budding.

Gemmule Formation:

Gemmule is an internal bud formed only in sponges. It has asexually produced mass or aggregation of dormant cells, the archaeocytes capable of developing into a new organism. The archaeocytes get coated by a thick resistant layer of secretion by amoebocytes. The gemmule is formed to overcome unfavourable conditions. On return of favourable conditions of water and temperature, the gemmules hatch and develop into a new individual. e.g. *Spongilla.*

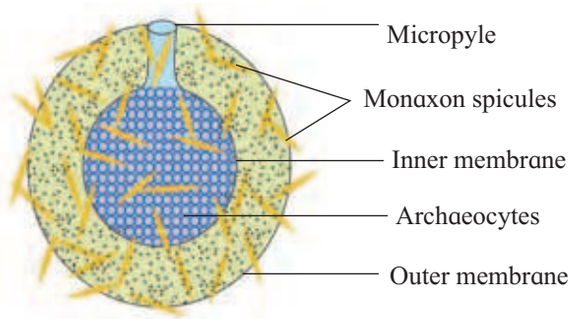


Fig. 2.1 : Gemmule

Budding:

It is a simple method of asexual reproduction normally occuring in favourable conditions. It is seen in a variety of animals like coelenterates (*Hydra* and corals) and in some colonial ascidians. In *Hydra*, a small outgrowth (bud) is produced towards the basal end of the body.

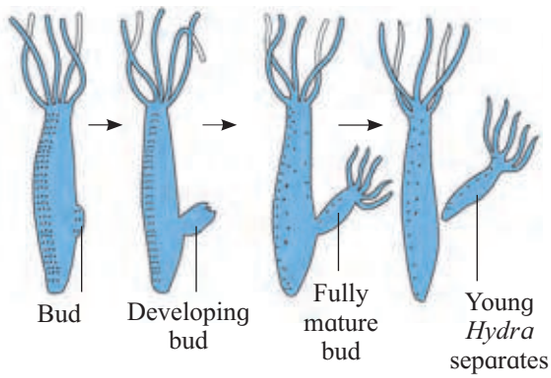


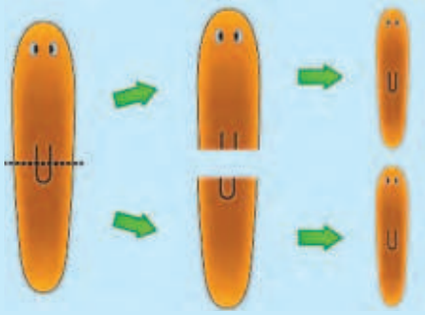
Fig. 2.2 : Budding in *Hydra*

It develops as a bud which grows and forms tentacles and develops (get transformed) into a new individual. This process is called **budding**. The young *Hydra* gets detached from the parent and becomes an independent new organism.

Do you know ?

Regeneration:

A word which in biology refers to the process observed in all living organisms from the unicellular bacteria upto the most complex multicellular forms e.g. humans. By this process, the organism can fundamentally repair or regrow or restore its lost or damaged part. Though it involves asexual processes, it differs distinctly from reproduction e.g. a damaged *Hydra* can regenerate its lost part. Similarly *Planaria* if wounded, its cells become active and regenerate lost part or organ back to its original state. They can also reproduce asexually by fragmentation. Also, it is seen in planarians that the anterior end exerts a pull on the posterior end resulting in a constriction in the middle part and splitting into two pieces. Each piece grows into a new *Planaria*. i.e. two clones of the original have been formed.



2.2 Sexual reproduction in animals :

It is the process which involves the production of offspring by the formation and fusion of gametes. It is also called **amphimixis**. In animals, gamete formation primarily involves meiosis.

The sexually reproducing animals show two main phases in their life time. The earlier **juvenile phase** mainly represents physical growth phase starting from birth. The animals can not reproduce sexually in this phase. The later **Reproductive maturity phase** is attained usually after physical growth is almost over. It involves growth and activity of the sex organs. The animal can reproduce sexually in this phase. Both these periods (phases) are of variable duration in different animals. After attaining sexual maturity, the animal exhibits various events, namely pre-fertilization (gametogenesis and gamete transfer), fertilization (fusion of male and female gametes) and post fertilization events (formation of zygote and embryogenesis).

The sexually reproducing animals show various breeding patterns. Some like the goat, sheep, and donkey are **seasonal breeders** while humans and apes are **continuous breeders**. They can breed throughout the year.

Human Reproduction :

Humans are sexually reproducing animals. The process of reproduction involves various sequential steps such as gametogenesis, insemination, internal fertilization (i.e. fusion of male and female gametes), zygote formation and embryogenesis, gestation and parturition.

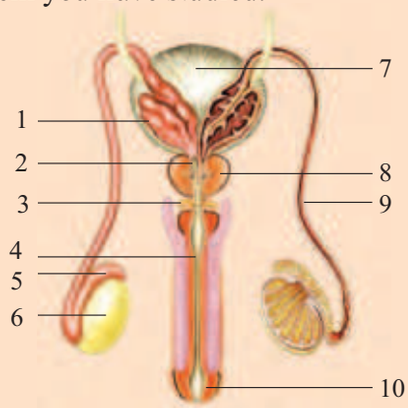
The gametes, sperms and eggs are produced by the primary sex organs, testis in male and ovary in female. Organs other than testis and ovary, are called secondary sex organs of the male and female. As male and female can be externally differentiated by certain specific features called **secondary sexual characters**, they are called **sexual dimorphic characters**. In males, presence of beard, moustache, hair on the chest, muscular body, enlarged larynx (Adam's apple) are secondary sexual characters while in females these characters are the developed breast, broader pelvis and high pitched voice.

A. Male Reproductive System :

It consists of the primary male organ (gonad) called testes, the accessory ducts and glands which form internal and external genitalia.

Can you recall?

Label the given male reproductive system you have studied.



a. Testes:

A pair of testes, mesodermal in origin, are formed in the lower abdominal cavity. They are located in a pouch called **scrotum**. During early foetal life, the testes develop in abdominal cavity and later they descend into the scrotal sac through a passage called **inguinal canal**. Each testis is oval in shape, 4 to 5cm long, 2 to 3cm wide and 3cm thick.

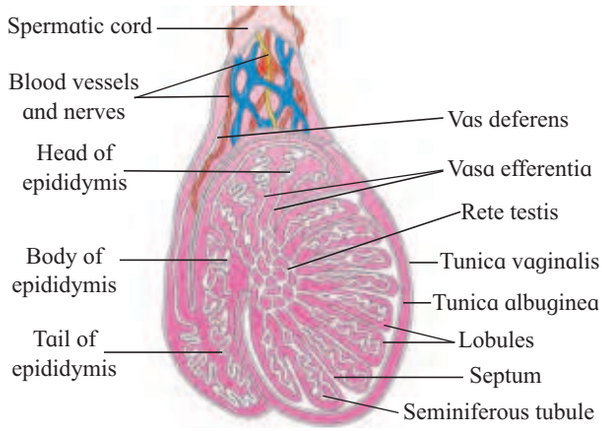


Fig. 2.3 : L. S. of testis

Histology of Testis:

The testis is externally covered by a collagenous connective tissue layer called **tunica albuginea**. Outer to it is an incomplete peritoneal covering called **tunica vaginalis**, and inner to it is **tunica vasculosa**, a thin membranous and vascular layer. Fibers from tunica albuginea divide each testis into about 200-300 testicular **lobules** (refer dig. 2.3 L. S. of testis). Each with 1-4 highly coiled seminiferous tubules. Each **seminiferous tubule** is internally lined by cuboidal germinal epithelial cells (spermatogonia) and few large pyramidal cells called **Sertoli** or **sustentacular cells**.

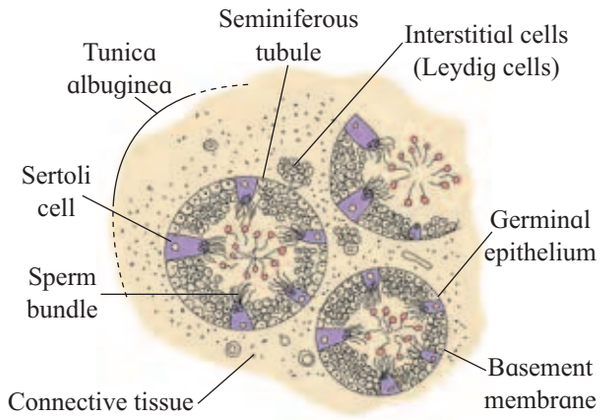


Fig. 2.4 : T. S. of Testis

The germinal epithelial cells undergo gametogenesis to form the **spermatozoa**. Sertoli cells provide nutrition to the developing sperms. Various stages of spermatogenesis can be seen in the seminiferous tubules. The inner most spermatogonial cell (2n), primary spermatocyte (2n), secondary spermatocyte (n), spermatids (n) and sperms (n). The **Interstitial** or **Leydig's cells** lie in between the seminiferous tubules. They secrete the male hormone **androgen** or **testosterone**.

Do you know ?

1. Presence of the peritoneal covering around the testis is an indication of its abdominal origin.
2. The testis are suspended in the scrotum by the spermatic cord.
3. Testosterone hormone stimulates the descent of testis and the fibro-muscular band called **gubernaculum** in the scrotum.
4. In some males a loop of the intestine may pass through the inguinal canal into the scrotum and cause a condition called **inguinal hernia**.

b. Accessory ducts:

The accessory ducts include rete testis, vasa efferentia, epididymis, vas deferens, ejaculatory duct and urethra. All the seminiferous tubules of the testis at the posterior surface form a network of tubules called **rete testis**. 12-20 fine tubules arising from rete testis are **vasa efferentia**. They carry the sperms from the testis and open into the **epididymis**. It is a long and highly coiled tube which is differentiated into an upper caput-, middle corpus- and lower cauda epididymis. The sperms undergo maturation in epididymis. Posteriorly, it leads into the **vas deferens** which travels upto the abdominal cavity and loops over the ureter to open into the urethra. Before doing so, it joins the duct of seminal vesicle to form the **ejaculatory duct**. The ejaculatory duct passes through the **prostate gland** and opens into the urethra. The **urethra** provides a common passage for the urine and semen and hence is also called **urinogenital duct**. In males the urethra is long and extends through the penis. It opens to the outside by an opening called the urethral meatus or **urethral orifice**. All the accessory ducts except urethra are present in pairs.

c. Glands:

The male accessory glands are as follows:

- **Seminal vesicles:** It is a pair of glands lying on the posterior side of urinary bladder. It secretes an alkaline **seminal fluid** which contains fructose, fibrinogen and prostaglandins. It contributes about 60% of the total volume of the semen. Fructose provides energy for sperm movement while fibrinogen coagulates the semen into a bolus for quick propulsion in the vagina. The prostaglandins stimulate reverse peristalsis in vagina and uterus aiding faster movement of sperms towards the egg in the female body.
- **Prostate gland:** It is a large and single gland made up of 20-30 lobes and is located underneath the urinary bladder. It surrounds the urethra and releases a milky white and slightly acidic prostatic fluid into the urethra. It forms about 30% of volume of semen. It contains citric acid, acid phosphatase and various other enzymes. The acid phosphatase protects the sperms from the acidic environment of vagina.

Activity :

Find the symptoms of prostate cancer.

Always Remember

Prostate cancer is cancer of the prostate gland. Men who are over 50 years of age and have a daily high consumption of fat, have an increased risk of prostate cancer.

Internet my friend

What is the role of prostaglandin?

- **Cowper's gland / Bulbourethral gland :** It is a small, pea sized and paired gland situated on either side of urethra. These

glands secrete an alkaline, viscous, mucous like fluid which acts as a lubricant during copulation.

Semen :

It is the viscous, alkaline and milky fluid (pH 7.2 to 7.7) ejaculated by the male reproductive system. Normally 2.5 to 4.0 ml of semen is given out during a single ejaculation and it contains about 400 million sperms. It contains secretion of the epididymis and the accessory glands for nourishing (fructose), neutralizing acidity (Ca^{++}, bicarbonates), activation for movement (prostaglandins).

d. External genitalia:

It includes the penis and the scrotum. The **penis** is the male copulatory organ. It is cylindrical and muscular with three bundles of erectile tissue- a pair of postero-lateral tissue called **corpora cavernosa** and a median **corpus spongiousm**. The swollen tip of the penis is called **glans penis**. It is covered by a loose fold of skin called **foreskin** or **prepuce**.

Scrotum :

It is a loose pouch of pigmented skin lying behind the penis and is divided into a right and left scrotal sac by a septum of tunica dartos made of smooth muscle fibres. The foetal testes are guided into and retained in the scrotum by a short fibro muscular band called **gubernaculum**. The testes remain suspended in scrotum by a spermatic chord. Failure of testis to descend into scrotum is called **cryptorchidism**. The failure also results in the sterility. The cremaster and dartos muscles of scrotum help in drawing testes close or away from the body. This helps in maintaining the temperature of the testis 2-3^{0}C lower than the normal body temperature, necessary for spermatogenesis.

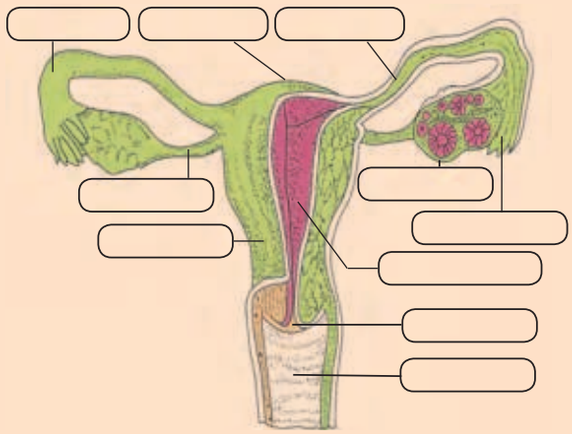
B. Female Reproductive System:

The female reproductive system consist of the following parts :

1. A pair of ovaries
2. A pair of oviducts
3. Uterus
4. Vagina
5. External genitalia (vulva)
6. A pair of vestibular glands
7. A pair of mammary glands

Can you recall?

Give labels to given female reproductive system:



1. Ovary : It is the primary female sex organ. Its main function is production of egg or ovum and the female reproductive hormones. It is solid, oval or almond shaped organ. It is 3.0 cm in length, 1.5 cm in breadth and 1.0 cm thick. It is located in the upper lateral part of the pelvis near the kidneys. Each ovary is held in position by ligaments by attaching it to the uterus and the abdominal wall. The largest of these is the broad ligament formed by a fold of peritoneum. It holds the ovary, oviduct and the uterus to the dorsal body wall. The ovarian ligament attaches ovary to the uterus. The ovary produces five hormones viz, estrogen, progesteron, relaxin, activin and inhibin.

Structure and development of the ovary :

Each ovary is a compact structure differentiated into a central part called medulla and the outer part called cortex. The cortex is covered externally by a layer of germinal

epithelium. The stroma or loose connective tissue of the medulla has blood vessels, lymph vessels, and nerve fibres. The outer cortex is more compact and granular. It shows large number of tiny masses of cells called ovarian follicles. These are collectively formed from the immature ova originating from cells of the dorsal endoderm of the yolk sac. The cells migrate to the gonadal ridge during embryonic development and divide mitotically. Now these cells are called **oogonia**. As the oogonia continue to grow in size they are surrounded by a layer of granulosa cells and form the rudiments of the ovarian follicles. The process of oogenesis starts much before the birth of the female baby and by the end of twelve weeks the ovary is fully formed. It has more than two million **primordial follicles** in it.

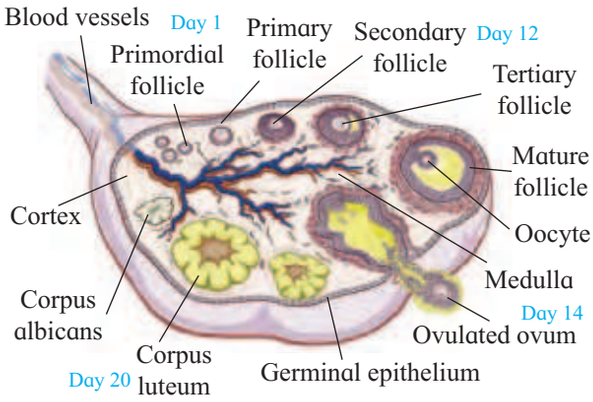


Fig. 2.5 : T.S. of ovary

The cells of **germinal epithelium** give rise to groups of oogonia projecting into the cortex in the form of cords called **egg tubes** of **Pfluger**. Each cord at its end has a round mass of oogonial cells called **egg nests**, from which the primordial ovarian follicles develop. Each primordial follicle has, at its center a large **primary oocyte** (2n) surrounded by a single layer of flat follicular cells. The primary oocyte starts with its meiotic division but gets arrested it at meiosis I. Of the two million primordial follicles embedded in the foetal ovary only about one million remain at birth and only about 60,000 - 80,000 remain at the time of **puberty**. The large scale destruction of the primordial follicles during growth is called **atresia**.

The development of the primordial follicles into mature or Graafian follicles restarts with the onset of puberty. During each menstrual cycle only one of the primordial follicle starts growing to form the **Graafian follicle**.

In each cycle, alternately one of the two ovaries produces the Graafian follicle.

The 1st menstrual cycle or **menarche** begins normally at about 13 years and Menopause i.e. stopping of the cycles happens at age 45 to 55 years. The period in between menarche and menopause is the reproductive age of the female and is approximately 32 years. In this time the female will be producing a maximum of about 416 eggs (32 ×13 = 416 eggs).

Ovarian histology of a mature female :

In the histology of ovary, we have discussed the primary structure of ovary. The following discussion includes the changes seen in a mature ovary, primarily in the cortex. The different stages of development of the oocyte can be seen. These changes in the ovary are cyclic, occuring during each menstrual cycle and it involves maturation of the primordial follicles into primary, secondary and Graafian follicles. Each primary follicle has multilayered cuboidal follicular cells. The stroma cells add **theca** over the follicle. It now changes into a **secondary follicle**. There is growth of the oocyte and the granulosa cells increase in number. They start producing the hormone estrogen. The secondary follicle grows into the **Graafian follicle** by addition of more follicular cells. As this process of maturation of follicles takes place, they begin to move towards the surface of ovary. The Graafian follicle presses against the thin wall of the ovary giving it a blistered appearance. The egg is released from the Graafian follicle during **ovulation** and the remaining part of the follicle changes into a temporary endocrine gland called **corpus**

luteum. If fertilization does not take place the corpus luteum degenerates into a white scar called **corpus albicans**.

Use your brain power

In t. s. of ovary, can all the stages of follicles be seen simultaniously?

Structure of Graafian follicle :

Graafian follicle is a mature ovarian follicle. An eccentric secondary oocyte is surrounded by a non-cellular layer of **zona pellucida** secreted by the vitelline membrane of oocyte. The outermost protective and fibrous covering is called **theca externa**. Inner to it is cellular **theca interna**. It produces the hormone estrogen. Inner to the theca interna, the follicular cells form the **membrana granulosa**. From the membrana granulosa the cells differentiate into **discus proligerus** and the **corona radiata** cells. **Cumulus oophorus** is the term used for the oocyte and surrounding granulosa cells . A fluid filled cavity called **antrum** lies between the oocyte and the **membrana granulosa**. It is filled with a fluid called **liquor folliculi**.

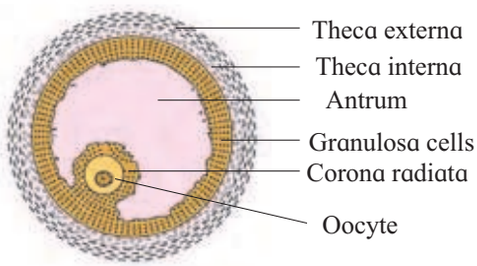


Fig. 2.6 : Graafian Follicle

2. Oviduct / Fallopian tube / Uterine tube: These are a pair of muscular ducts lying horizontally over the peritoneal cavity. The proximal part of the tube lies close to the ovary, and distally it opens into the uterus. Each tube is 10 to 12 cm in length. It is internally lined by ciliated epithelium. It can be divided into three regions :

a. **Infundibulum** : The proximal funnel like part with an opening called **ostium** surrounded by many finger like processes called **fimbriae** (of these at least one is long and connected to the ovary). The cilia and the movement of fimbrae help in driving the ovulated egg to the ostium.

b. **Ampulla :** It is the middle, long and straight part of the oviduct. Fertilization of the ovum takes place in this region.

c. **Isthmus / Cornua :** The distal narrow part of the duct opening into the uterus.

3. Uterus : It is commonly also called the womb. It is a hollow, muscular, pear shaped organ, located above and behind the urinary bladder. It is about 7.5 cm long, 5 cm broad and 2.5 cm thick. The uterus can be divided into three regions :

a. **Fundus :** It is the upper dome shaped part. Normally implantation of the embryo occurs in the fundus.

b. **Body :** It is the broad part of the uterus which gradually tapers downwards.

c. **Cervix :** It is the narrow neck about 2.5 cm in length. It extends into the vagina. Its passage has two openings : an **internal os** towards the body, and an **external os** towards the vagina.

Internally the uterine wall can be distinguished into three layers : Outermost **perimetrium**, middle thick muscular **myometrium**, made up of thick layer of smooth muscles. Vigorous contractions of these muscles cause **labour** during the **parturition** (child birth). The innermost layer called **endometrium** or mucosal membrane is made up of stratified epithelium. The thickness of this layer regularly undergoes changes in during the menstrual cycle. It is richly supplied with blood vessels and uterine glands. These provide nourishment to the developing foetus.

Do you know ?

Uterus cancer:

Most of the uterine cancers begin in the layer of cells that form the lining of endometrium of uterus.

Symptoms : Abnormal bleeding between periods, vaginal bleeding after menopause, an abnormal watery, blood-tinged discharge from vagina, pelvic pain.

Detection : It is diagnosed with Pap smear test, biopsy, Ultrasound.

Treatment : Chemotherapy, radiation, surgical removal of uterus (hysterectomy).

4. Vagina : It is a tubular, female copulatory organ, 7 to 9 cm in length. It lies between the cervix and the vestibule. The vaginal wall has an inner mucosal lining, the middle muscular layer and an outer adventitia layer. The mucosal epithelium is stratified and non-keratinised and stores glycogen. There are no glands but the cervical secretion of mucus is recieved in the vagina. The opening of the vagina into the vestibule is called **vaginal orifice**. This opening is covered partially by a fold of mucus membrane called **hymen**. The vagina acts as a passage for menstrual flow as well as birth canal during parturition.

5. External genitalia : The external genital organs of female include parts external to the vagina and are collectively called '**vulva**' (covering or wrapping), or **pudendum**. They include the following parts :

a. Vestibule - It is a median vertical depression of vulva enclosing the urethral and vaginal opening.

b. Labia minora - These are another pair of thin folds inner to the labia majora with which they merge posteriorly to form the fore chette while towards anterior end they converge into a hood-like covering around the clitoris.

c. Clitoris - A small conical and sensitive projection lying at the anterior end of labia minora. It has a pair of erectile tissue - The corpora cavernosa and is homologous to the penis.

d. Labia majora - These are a pair a fleshy folds of skin forming the boundary of vulva. They are homologous to the scrotum. They surround and protect the other parts of external genitalia and enclose the urethral and vaginal openings in the vestibule.

e. Mons pubis - It is a fleshy elevation above the labia majora. The Mons pubis and outer part of labia majora show pubic hair.

6. Accessary glands / Vestibular glands / Bartholin's glands : It is a pair of glands homologous to the Bulbourethral or Cowper's glands of the male. They open into the vestibule and release a lubricating fluid.

Mammary glands :

Accessory organs of female reproductive system for production and release of milk after parturition. Development of the mammary gland occurs at puberty under the influence of estrogen and progesteron. Lactotropic hormone (LTH) or prolactin helps in development of lactiferous tubules during pregnancy.

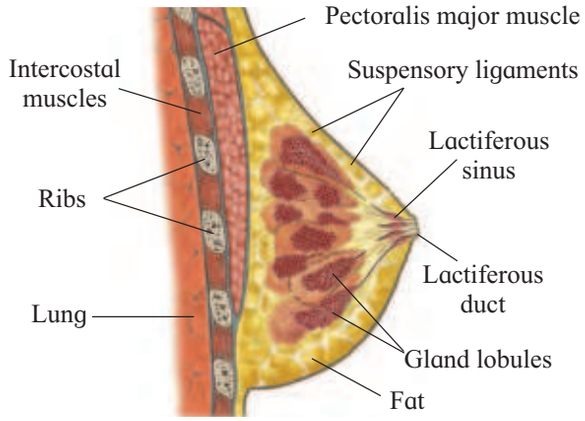


Fig. 2.7 : Section view of Mammary gland

The mammary glands are a pair of rounded structures present in the subcutaneous tissue of the anterior thorax in the pectoral region (from

2nd to 6th rib). These are modified sweat glands. Each mammary gland contains fatty connective tissue and numerous lactiferous ducts. The glandular tissue of each breast is divided into 15-20 irregularly shaped mammary lobes, each with alveolar glands and lactiferous duct. Alveolar glands secrete milk which is stored in the lumen of alveoli. The alveoli open into mammary tubules. The tubules of each lobe join to form a mammary duct. Many mammary ducts join to form a wider mammary ampulla, which is connected to lactiferous duct. These converge towards the nipple located near the tip of the breast. It is surrounded by a dark brown coloured and circular area of the skin called **areola**.

Do you know ?

Breast cancer :

Symptoms: First symptom of breast cancer is a lump in breast or underarm. Lump is painless. Swelling of all or part of breast. Skin irritation, Breast or nipple pain, nipple retraction, Redness, scaliness or thickening of nipple or breast skin, discharge, etc.

Detection: Mammogram (x-ray), ultrasound, MRI, Biopsy, Blood test.

Treatment: Radiation therapy, chemotherapy lumpectomy, Mammoplasty

Do you know ?

Weaning : Mother's milk is replaced gradually by solid food after some time. This process is called weaning.

Puberty / Sexual maturity in Males :

Puberty is the age at which the reproductive system becomes functional, sex organs begin to produce gametes and sex hormones. In males the onset of puberty occurs at age 12-15 years. Under the influence of testosterone, the secondary sexual characters appear. Thereafter it remains functional throughout the life.

Puberty / Sexual maturity in Females :

The reproductive system becomes functional at puberty. It is characterised by onset of menstrual cycle also called **menarche**, which usually occurs at age 10-14 years. However, unlike in the males, the mature females show cyclic changes in their reproductive system- the menstrual cycles. These cycles continue only upto **menopause**. This normally happens at age 45-50 years. The period from menarche to menopause is thus the reproductive age of the female. The female is unable to bear children (by natural method) after menopause. Menarche, menstrual cycles and menopause are controlled by gonadotropic hormones.

2.3 Menstrual cycle (Ovarian cycle):

Menstrual cycle is the characteristic feature of primates including human. It involves a series of cyclic changes in the ovary and the female reproductive tract, mainly in the uterus. These changes take place under the effect of gonadotropins and the ovarian hormones respectively. The cycles are repeated with a periodicity of approximately 28 days. The middle of each cycle is characterised by the release of an egg. This egg in every cycle comes alternately from one of the two ovaries. The cycle is divided into four phases.

a. Menstrual phase:

The begining of each cycle is taken as the first day where menses or loss of blood (45-100ml) takes place and it lasts for approximately five days (average 3-7 days).

Endometrium of uterus breaks down under the effect of prostaglandins released due to decreased levels of progesteron and estrogen. Due to this blood, tissue fluid, mucus, endometrial lining and the unfertilized oocyte is discharged through vagina. The endometrial lining becomes very thin i.e. about 1 mm. The menstrual discharge continues for an average of 5 days, however this blood does not clot

due to presence of fibrinolysin. Menstrual phase occurs when an ovulated egg does not get fertilized and it is thereby shed out along with the menstrum. It is thus called 'funeral of unfertilized egg'.

During these five days, many primordial follicles develop into primary and few of them into secondary follicles under the effect of FSH.

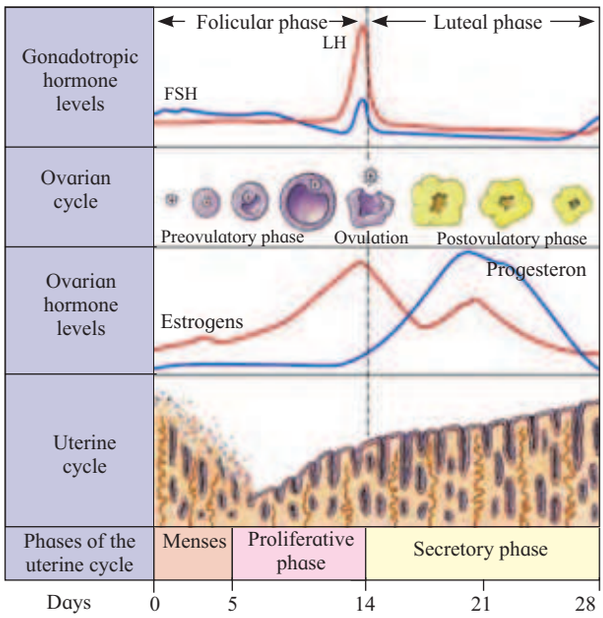


Fig. 2.8 : Hormones and the menstrual cycle.

Internet my friend

1. Enlist the examples of primates and non primate animals.
2. Collect information about female reproductive cycles differentiating both primates and non-primates.

b. Proliferative phase / Follicular phase / Post menstrual phase:

This phase is the duration between the end of menstruation and release of ovum (ovulation). Duration of this phase is more variable than other phases. Generally, it extends from **5th to 13th** day of menstrual cycle.

A few (6 to 12) secondary follicles proceed to develop but usually one of them develops into a graafian follicle (mature follicle). The other secondary follicles degenerate. This process of degeneration is called **atresia**. Developing secondary follicles secrete the hormone estrogen. The stimulation for proliferation of new follicles is influenced by GnRH which stimulates release of FSH.

Endometrium begins to regenerate under the effect of gradually increasing quantity of estrogens. Regeneration also involves formation of endothelial cells, endometrial or uterine glands and network of blood vessels. Thickness of endometrium reaches 3-5 mm.

c. Ovulatary phase:

It is the shortest phase of menstrual cycle. It involves rupturing of the mature graafian follicle and release of ovum (secondary oocyte) into the pelvic cavity; usually on **14th** day of menstrual cycle. Rapid secretion of LH by positive feedback mechanism causes the mature follicle to rupture. Ovulation may be accompanied by mild or severe pains in lower abdomen.

d. Secretory phase / Luteal phase:

Duration of this phase is between the ovulation and beginning of the next menses. This phase is the longest phase. It lasts for 14 days; from **15th to 28th** day of the cycle.

After release of secondary oocyte, remaining tissue of graafian follicle transforms into corpus luteum under the effect of LH. Corpus luteum begins to secrete progesteron and estrogens. The ovulated egg may get fertilized within 24 hours. However, in the absence of fertilization, corpus luteum can survive for only two weeks and then degenerate into a white scar called **corpus albicans**.

The corpus luteum releases progesteron, small amount of estrogens and inhibin. Under the influence of these hormones, the endometrial glands grow, become coiled and start uterine secretions. Endometrium becomes more vascularized and thickens up to 8-10 mm. Inhibin stops secretion of FSH. These changes are necessary for fertilization and subsequent implantation.

However, if the ovulated egg gets fertilized and the embryo is implanted, there is secretion of human chorionic gonadotropin (hCG), which extends the life of corpus luteum and stimulates it's secretory activity. Presence of hCG in maternal blood and urine is an indicator of pregnancy. In absence of fertilization, next menstrual cycle begins.

Always Remember

Hygiene practices during menstruation :

- Keep the pubic area clean.
- Change the sanitary napkin every 4-5 hours.
- Maintaining personal hygiene during menstruation is important to reduce the risk of infection.
- Dispose used sanitary napkin properly.
- Using damp and dirty clothes or using a sanitary napkin for a longer time can act as a perfect environment for growth and multiplication of harmful bacteria and lead to infections.

Use your brain power

Why the menstruation is painful in some women?

Can you tell?

Can you tell the names of primates who show the presence of menstrual cycle?

2.4 Gametogenesis:

The gametogenesis is the process of formation of gametes in sexually reproducing animals. The male gamete is sperm and the female gamete is ovum or egg. The gametes are formed from primordial germ cells of gonads.

Spermatogenesis:

The process of formation of the male gamete (sperm) or spermatozoa from the germinal epithelium of testis is called spermatogenesis. At the onset of puberty, the hypothalamus begins secretion of gonadotropin releasing hormone (GnRH). It initiates the significant increase in the secretion of follicle stimulating hormone (FSH) which induces spermatogenesis. Each seminiferous tubules is lined by a single layer of cuboidal epithelial cells called germinal epithelium.

The cells of germinal epithelium undergo spermatogenesis to produce sperms. Process of spermatogenesis involves three phases.

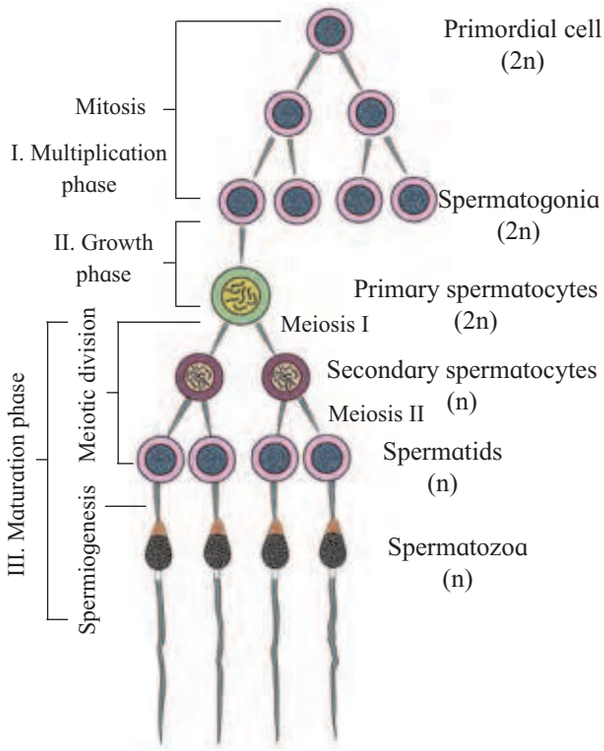


Fig. 2.9 : Spermatogenesis

I. Multiplication phase: The primordial germ cells (2n) of seminiferous tubules undergo repeated mitotic divisions to produce large number of spermatogonia (2n). Each spermatogonium is diploid and with 46 chromsomes.

II. Growth phase: Some of the spermatogonia stop dividing and grow in size to develop into primary spermatocytes (2n) due to accumulation of food.

III. Maturation phase: It involves meiotic or reduction division. The spermatocyte undergoes the first phase of meiotic division (meiosis I) leading to formation of two haploid cells called secondary spermatocytes (n), which are with 23 chromosomes each. The secondary spermatocyte undergoes second phase of meiotic division (meiosis II) to produce four haploid spermatids. The spermatid is non-motile and non-functional. It gets transformed into a functional spermatozoa by the process called **spermiogenesis**. During this process of change, the spermatids remain held to each other and to the sertoli cells by cytoplasmic bridges. The sperm heads remain attached to the sertoli cells and their tails hanging in the lumen of seminiferous tubule. During spermiogenesis, length of spermatid increases. Centrioles are rearranged as primary and distal centrioles. Mitochondria become spirally coiled and acrosome is formed from golgi complex.

Structure of sperm:

Sperm is the male gamete. It is a motile, microscopic elongated cell. It is divisible into three parts- head, middle piece and tail.

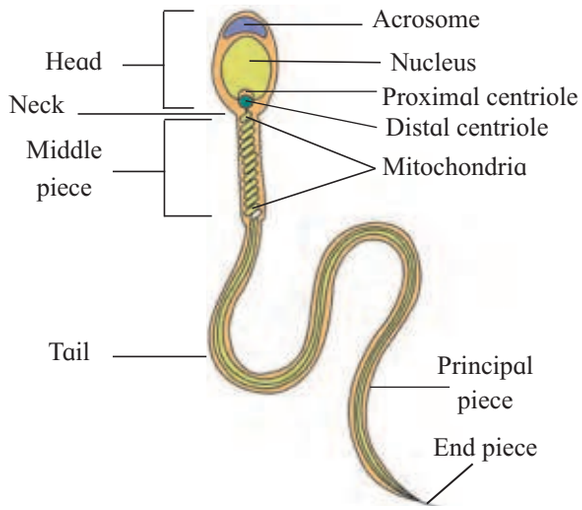


Fig. 2.10 : Structure of Sperm

Head: The sperm head is oval in shape and contains haploid nucleus. Above the nucleus, there is a cap like structure called **acrosome**. It is formed from the golgi body. Acrosome contains hydrolytic enzymes; hyaluronidase and proteolytic enzymes like zona lysins and corona penetrating enzymes.

Neck: It is a very short region having two centrioles i.e. proximal centriole and distal centriole.

Middle piece: It has an axial filament surrounded by 10-14 spiral turns of mitochondria (nebenkern). It produces energy necessary for the movement of sperm.

Tail: It is a long, slender and tapering part containing cytoplasm and fine thread- axial filament. The axial filament arises from the distal centriole and travels through out the length of tail. It is partly surrounded by plasma membrane (main piece). The part without plasma membrane is called end piece.

Oogenesis:

It is process of formation of the haploid female gamete i.e. egg or ovum from the diploid germinal epithelium. It involves the process of meiosis (and mitosis). Like spermatogenesis, oogenesis process can be divided into three stages :

I. Multiplication phase
II. Growth phase
III. Maturation phase

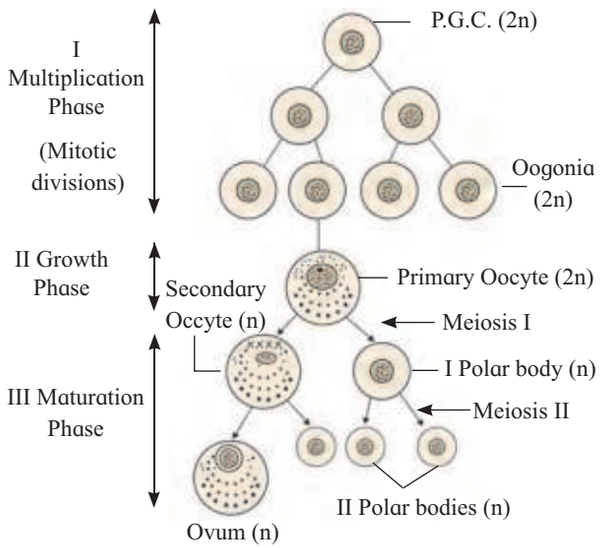


Fig. 2.11 : Oogenesis

Activity :

Prepare a chart of comparison between spermatogenesis and oogensesis.

I. Multiplication phase: In this stage, the primary germinal cells PGCs (2n) of ovary undergo repeated mitotic division to form millions of gamete mother cells or oogonial cells (2n). This process is completed in the embryonic stage of human females.

II. Growth phase: Some of the oogonia stop division and begin to increase in size and form the primary oocytes (2n). Cellular organelles like ER, golgi appratus and mitochondria increase in number.

III. Maturation phase: Oogenesis takes place in the ovaries. The process is initiated prior to birth of the female baby. The primary oocytes (2n) enter the maturation phase which includes meiotic division (Meiosis I and Meiosis II). The diploid primary oocytes undergo meiosis I (reduction division) to form 2 haploid daughter cells. This division is peculiar in females as both the daughter cells are with haploid number of chromosomes i.e. 23 chromosomes. But due to unequal division of cytoplasm, of the 2 daughter cells produced, one is a large cell called secondary oocyte (n) and another is a small cell called 1st polar body (n). Normally the 1st polar body does not enter meiosis II. The secondary oocyte (n) proceeds meiosis II, only upto metaphase II. It's division is further stopped or arrested at this stage. The secondary oocyte is shed from the graafian follicle and ovary. The restart and completion of meiosis II will happen only with entry of the sperm. This last phase is usually completed in the ampulla of the fallopian tube at the time of fertilization. In this division also, the two unequal daughter cells are formed- the large cell is ovum (n) and the small cell is 2nd polar body (n). The ovum (n) so formed functions as the female gamete and is ready for fertilization. (Completion of meiosis II and completion of fertilization go hand in hand. If the secondary oocyte does not receive the sperm / spermatozoa, it is shed off along with menstrum).

Structure of secondary oocyte:

In human, unfertilized egg when ovulated i.e. released from the ovary is actually the secondary oocyte. It is non-cleidoic (without shell) and microlecithal (yolk is present in very small quantity). It is approximately 0.1mm (100 microns) in size. It is rounded, nonmotile and haploid female gamete. The nucleus of the egg appears large and is called **germinal vesicle**. Typical nucleus or pronucleus is formed at the time of fertilization. The cytoplasm of egg is also called **ooplasm**. It is devoid of centrioles. The egg is surrounded by various coverings.

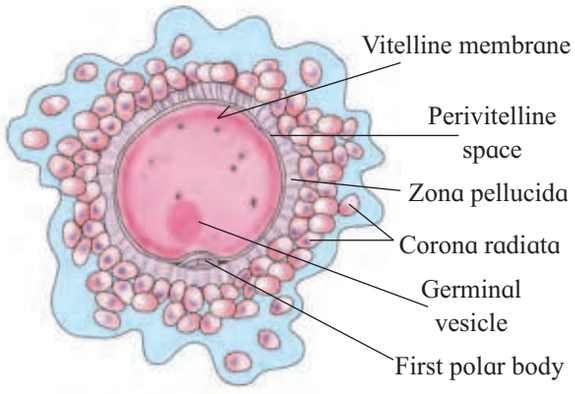


Fig 2.12 : Unfertilized egg/ Ovum

The egg membrane is called vitelline membrane. It secretes a non-cellular glycoproteinous membrane, **zona pellucida** on its outside. Adhering to the outer surface of zona pellucida are several radially elongated cells forming the **corona radiata**. These cells are derived from the innermost layer of granulosa cells. They are firmly held to the zona pellucida and to each other by hyaluronic acid (mucopolysaccharide). Between the vitelline membrane and the zona pellucida is a fluid filled perivitelline space. The first polar body lies in this space.

The egg shows polarity. The side having germinal vesicle and first polar body is called **animal pole** while the side opposite to it is called **vegetal pole**.

2.5 Fertilization / Syngamy:

Sexual reproduction primarily involves formation and fusion of gametes. Fertilization is the later process which involves fusion of the haploid male and female gametes resulting in the formation of a diploid zygote (2n). Like in other mammals, in humans the process of fertilization is internal and it usually takes place in the ampulla of the fallopian / uterine tube. The fertilized egg or zygote will develop into an embryo and this process occurs within the uterus.

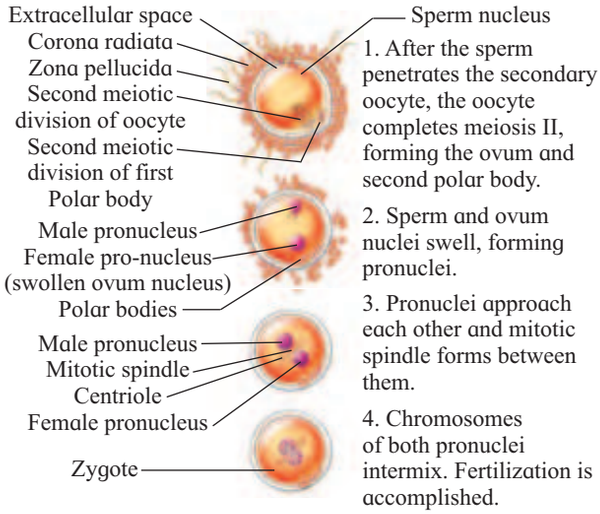


Fig. 2.13 : Process of Fertilization

Mechanism of fertilization :

Semen released during ejaculation has sperms and some secretions. The coagulated semen now undergoes liquification and sperms become active. The mechanism of fertilization is as follows :

a. Movement of sperm towards egg:

It involves capacitation of sperms reaching the vagina. Here as many as 50% are demotilised / broken / destroyed. Remaining sperms undergo capacitation. This process requires 5-6 hours. Acrosome membrane becomes thin, Ca^{++} enters the sperm and their tails begin to show rapid whiplash movements.

Always Remember

Indian law under the Hindu marriage Act has defined the marriageable age of a boy and girl. As per this act, minimum age for boy must be 21 and for a girl must be 18 years, at the time of marriage.

As a result of capacitation, sperms become extra active and begin to start moving upwards from vagina to uterus and to the oviducts. The prostaglandins activate the sperms. The vestibular secretions of the female also enhance sperms motility. The sperms swim at an average speed of 1.5 to 3.0 mm/min.

Sperms reach upto the ampulla as a result of their own swimming and partly by contraction of uterus and fallopian tubes stimulated by oxytocin of female. After capacitation the sperms may reach ampulla within 5 minutes. Sperms can remain viable for 24-48 hours (Ovum for about 24 hours).

b. Entry of sperm into the egg : Out of 200 to 400 million sperms, only few hundred manage to reach the ampulla. Though many sperms reach the ampulla but only a single sperm fertilizes the ovum. A sperm after reaching the egg / ovum comes to lie against it. Its acrosome releases lysins : hyaluronidase and corona penetrating enzymes. They separate and dissolve the cells of corona radiata, so the sperm head passes through the zona pellucida of egg. The zona pellucida has fertilizin receptor proteins (ZP3, ZP2). The fertilizin binds to specific acid protein- antifertilizin of sperm. It brings about attraction of sperms to the egg to enhance fertilization. Fertilizin-antifertilizin interaction is species specific. Thus, the fertilizin-antifertilizin reaction is also called compatibility reaction.

Acrosome reaction : As the sperm head touches the zona pellucida in the animal pole region, its acrosome covering ruptures to release lytic enzymes, acrosin or zona lysin. They act on the zona pellucida at the point of contact. This causes egg reaction - A small fertilization cone / cone of reception is formed on the egg membrane. The sperm head comes in contact with this cone. It results in production of a weak wave of depolarisation. Plasma membrane of the both cells dissolve at the point of contact. The sperm nucleus and the centrioles enter the egg, while other parts remain outside.

As soon as the sperm head touches the vitelline membrane, a cortical reaction gets activated changing the vitelline membrane into a fertilization membrane by deactivating the sperm receptors of zona pellucida. A distinct perivitelline space is created around the fertilization membrane. This prevents any further entry of other sperms into the egg i.e. polyspermy is avoided.

Do you know ?

1. What would happen if the sperm fuses with the egg before it reaches the fallopian tube?
2. What is ectopic pregnancy? Can ectopic pregnancy continue upto full term?

c. Activation of ovum : The ovum before fertilization was at metaphase II stage. With a contact of sperm head to the vitelline membrane of egg, it gets activated to resume and complete its meiosis II. With this it gives out the second polar body. The germinal vesicle organizes into female pronucleus. At this stage, it is the true ovum or egg.

Fusion of egg and sperm : The coverings of male and female pronuclei degenerate allowing the chromosomal pairing. This results in the formation of a **synkaryon** by the process called **syngamy** or **karyogamy**. The zygote is thus formed. The proximal centriole received from the sperm helps in formation of the synkaryon spindle and cleavage of cell into two blastomeres.

Internet my friend

Find out about extraembryonic membranes.

Significance of fertilization :

- Secondary oocyte completes the process of oogenesis and is transformed into a mature ovum (n).
- The diploid chromosome number is restored in the zygote by the process of syngamy.
- The ovum lacks the centrioles necessary for further divisions, are received from the sperm during fertilization.
- Fertilization involves fusion of male and female gametes from the two parents. It results in variations which are significant to evolution.
- Sex of the offspring is determined.

Always Remember

- Secondary oocyte (egg) is ovulated after LH surge at about the middle of menstual cycle i.e. day 14.
- Egg (arrested at metaphase II) reaches the ampulla of uterine tube in 12-24 hours after ovulation. The cilia and the fimbriae of the fallopian tube help, direct the egg to ostium.
- During coitus/ intercourse semen is deposited into the vagina of the female. This process is called insemination.
- Human male during ejaculation gives out about 2-4ml of semen with an average count of 200-400 million sperms.

2.6 Embryonic development :

The zygote formed as a result of syngamy is activated to divide.

Cleavage :

It is the process of early mitotic division of the zygote into a hollow multicellular blastula. It does not involve the growth of the daughter cells. The cells formed by cleavage are called **blastomeres**.

Since, there is no growth phase between the cleavages, the size of blastomeres will be reduced with every successive cleavage. As the size reduces, the metabolic rate increases. Subsequent cleavages are thus faster than earlier one. This requires rapid replication of DNA and high consumption of oxygen.

Process of cleavage : In human, cleavage is holoblastic i.e. the whole zygote gets divided. The cleavage planes may be longitudinal or meridional and equatorial or horizontal. It is radial and indeterminate i.e. fate of each blastomere is not predetermined.

Internet my friend

What is meroblastic cleavage? In which organisms, is it observed?

The 1st cleavage in the zygote is meridional and occurs at about 30 hours after fertilization. It divides longitudinaly into two blastomeres, one slightly larger than the other. The 2nd cleavage is also longitudinal but at the right angle to the 1st one and occurs after 30 hours of 1st cleavage. The 3rd cleavage is horizontal. After 3rd cleavage the embryo is in 8-cell stage. As the cleavages are going on the young embryo is gradually being pushed towards the uterus. By the end of 4th day after fertilization, embryo is a solid ball of 16-32 cells and externally looking like mulberry. This stage is thus called **morula**. The morula shows cells of two types : smaller, clearer cells towards the outer side and inner cell mass of larger cells. Cells are compactly arranged. Till the formation of morula the zona pellucida is retained around the embryo and thus, there is no change in the overall size from zygote to morula. The morula reaches the isthmus and gains entry into the uterus by the end of day 4.

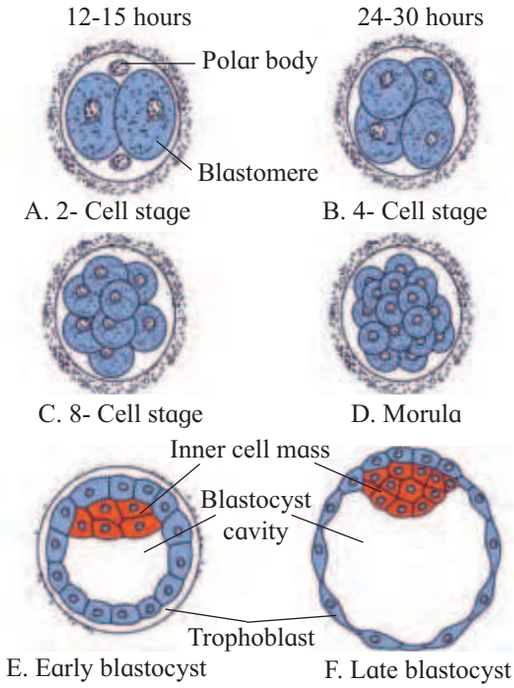


Fig. 2.14 : Process of cleavage and formation of Blastula

Blastulation :

Blastulation is the process of formation of the hollow and multicellular blastocyst. The embryo (blastocyst) that enters the uterus remains floating in uterine cavity for 2-4 days after its entry. i.e. till the end of 7th day after fertilization. The outer layer of cells seen in the morula now form the layer called **trophoblast**.

Cells from the trophoblast begin to absorb the glycogen rich uterine milk. The blastocyst doubles in size from 0.15 mm to 0.30 mm. With more fluid entering inside the blastocyst cavity is formed. These outer cells become flat and are called **trophoblast cells** (since they help only in absorbing nutrition for the developing embryo). The inner larger cells form **inner cell mass** or **embryoblast** (the embryo proper develops from the embryoblasts). These remain attached

to the trophoblasts on only one side. The trophoblast cells in contact with the embryonal knob are called **cells of Rauber**. At this stage, the blastocyst shows polarity. The side with inner cell mass is called the embryonal end and the side opposite to it is the abembryonal end. By the end of the 7th day the blastocyst is fully formed. It is now ready for implantation and gastrulation. The function of zona pellucida is to prevent the implantation of the embryo at an abnormal site. It does not expose the sticky and phagocytic trophoblast cells till it reaches the implantation site i.e. within the uterus, hence zona pellucida now ruptures.

Can you recall?

What do you mean by Monozygotic Dizygotic and Conjoined twins.

Implantation :

The blastocyst after its formation, gets implanted or embedded into the endometrium of the uterus. This process usually begins on day 7 after fertilization and by end of 10th day, the embryo is completely burried inside the endometrium. The embryo usually implants in the region of the fundus of uterus. In the process, the embryo attaches itself by its embryonic pole, close to the endometrium. The trophoblast cells of the animal pole have the power to stick to the uterine wall. Rapid division of the trophoblast cells lying against the embryonal knob, takes place. It results in the formation of two distinct layers- syncytiotrophoblast and cytotrophoblast. The outer layer, **syncytiotrophoblast** is syncytium i.e. a layer of protoplasm with many nuclei. It gives out processes which extensively invade the endometrium. The lytic enzymes secreted by the trophoblasts, rupture the endometrial cells thereby making a burrow, into which the embryo begins to get implanted. By the end of the 10th day the whole embryo is deeply embedded into the endometrium, completing the process of implantation.

The inner layer of cells is called **cytotrophoblast** (cells with defined membrane) since, the cells retain their cell boundaries.

Gastrulation :

It is the process of formation of 'gastrula' from the blastocyst. In the gastrula stage, there is slowing of the rate of cleavage or divisions but there are two important events that take place actively :

a. Differentiation of blastomeres : This process results in the formation of three germinal layers i.e. ectoderm, mesoderm and endoderm from the cells of the embryoblast.

b. Morphogenetic movements : These are different types of movements to reach their definite place in the embryo.

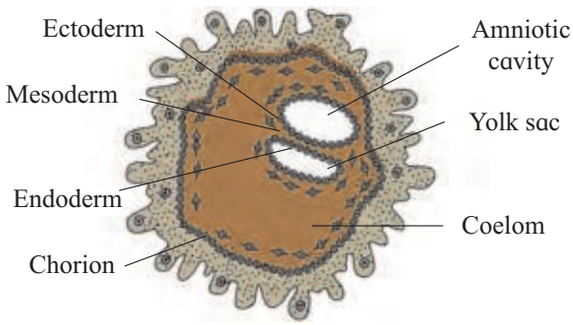


Fig. 2.15 : V. S. of late Gastrula

Gastrulation begins in the embryoblast cells on about 8th day after fertilization. Cell on the free end of inner cell mass called hypoblasts (primitive endoderm) become flatend, start dividing and grows downward towards the blastocoel, cavity of blastocyst. This layer called endoderm is first to differentiate. It grows within the blastocoel and forms a sac called **Yolk sac**. The remaining cell of the inner cell mass, in contact with cells of Rauber are called epiblasts (primary ectoderm). Both layers form a flat, bilaminar embryonal disc.

After formation of endoderm the second layer to be differentiated is the ectoderm. Cells of epiblast divide and redivide and move in such a way that they enclose the amiotic cavity.

Table 2.16 : Fate of germinal layers:

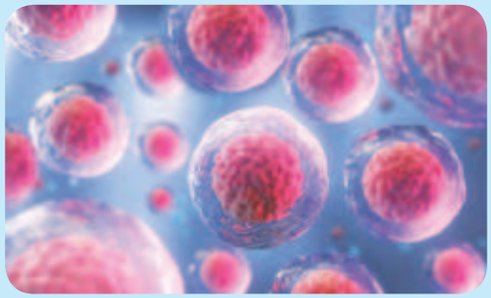
Ectoderm	Mesoderm	Endoderm
Ectoderm gives rise to epidermis of skin, hair, nails, sweat glands, salivary glands, mammary glands, lacrimal glands, sebaceous glands, cornea, lens, retina, conjunctiva, nasal epithelium, enamel of teeth, internal and external ear, foregut, hindgut, adrenal medulla, anterior and posterior pituitary, pineal gland, entire nervous system.	Mesoderm forms all types of muscles (except iris muscles and ciliary muscles of eye which originate from ectoderm), connective tissues, dermis of skin, adrenal cortex, heart, blood, blood vessels, lymphatic vessels, middle ear, dentine of teeth, urinary and reproductive ducts, gonads, kidneys, sclera and choroid of eye.	Endoderm develops into epithelium of mid- gut, glands of stomach and intestine, tongue, tonsils, lungs, trachea, bronchi, larynx, urinary bladder, vagina, liver, pancreas, thyroid gland, parathyroid gland, thymus gland, Eustachian tube, epithelium of urethra, lining of middle ear.

The floor of this cavity has the embryonal disc. The pyramidal cells of the disc towards the amniotic cavity form the embryonal ectoderm. The roof of amniotic cavity is lined by amniogenic cells. Later, these cells divide and redivide to form the amnion. Amnion is an extra embryonic membrane that surrounds and protects the embryo. As a result of all these changes, the bilaminar embryonic disc is positioned in between amniotic cavity and Yolk sac.

Actual gastrulation occurs about 15 days after fertilization, in which the bilaminar embryonic disc is transformed into trilaminar embryonic disc. This transformation occurs by division, rearrangement and migration of cells of epiblast. It begins with formation of primitive streak and a shallow groove on the surface is called primitive groove. This streak progresses from posterior to anterior end of embryo. From site of a primitive streak, a third layer of cells called mesoderm extends between ectoderm and endoderm. Anterior end of primitive groove communicates with yolk sac by an aperture called blastopore (future anus). The embryonal disc now has differentiated into three layers- ectoderm, mesoderm and endoderm. The further process after gastrulation is called histogenesis followed by **organogenesis**.

Do you know ?

Stem cells: These are undifferentiated somatic cells of a multicellular organism. They are capable of giving rise to many more cells of the same type or they can also differentiate into other type of cells. Bone marrow cells, blood stem cells cord cells or umbilical cord cells are examples of stem cells. They can be used in the treatment of Parkinson's disease, Alzheimer's disease, Diabetes, Leukemia, Arthritis, etc.



2.7 Pregnancy :

It is the condition of carrying one or more embryos in the uterus. It is also called **gestation**. It refers to the period between fertilization of the egg, upto parturition. The average period of pregnancy in human lasts for 266 days from fertilization or **280 days** (266+14) counted from LMC- Last Mensturation Cycle. This pregnancy peroid of approximately nine months is divided into three trimesters of three months each.

First Trimester :

(Period from fertilization to 12th week)

It is the time of most radical changes in mother and embryo. The embryo receives nutrients in the first 2-4 weeks directly from the endometrium. It is the main period of organogenesis or the development of body organs. By the end of eight weeks, the major structures found in the adult are formed in the embryo in a rudimentary form. The embryo is now called foetus and is about 3cm long. The arms, hands, fingers, feet, toes are formed and the foetus can open and close its mouth and fists. CNS is fully formed, working of excretory and cirulatory systems begins. Movements of foetus begin but mother can not feel it. Heart beat can be heard from 6th week. At the end of first trimester foetus is about 7-10 cm long.

Meanwhile, the mother's body also undergoes rapid changes. Progesterone level becomes high and menstual cycle is suspended till the end of pregnancy. High levels of progesterone initiate changes in her reproductive system. The maternal part of placenta grows, the uterus becomes larger. In this period, the mother experiences '**morning sickness**' (nausea, vomiting, mood swings, etc).

Second Trimester :

(Period from 13th to 26th week)

It is the period of rapid growth of foetus. The uterus grows enough for the pregnancy to become obvious. The foetus is very active and grows to about 30 cms. Development of brain begins. Hormone levels stabilize, human chorionic gonadotropin (hCG) declines, the corpus luteum deteriorates (regresses) and the placenta completely takes over the production of progesterone which maintains the pregnancy.

Ultrasound (sonography) at 18-20 weeks shows baby's growth and position. From this estimated due date of delivery can be established. Baby's movements can be easily felt by the mother. Head has hair, eyebrows and eyelashes appear, pinnae are distinct. The baby reaches half the size of a newborn.

Third (final) Trimester :

(Period from 27th week till the parturition)

The foetus grows to about 3-4 kg in weight and 50 cms in length. Eyes are open. There is gain in body weight. As the foetus grows, the uterus expands around it, the mother's abdominal organs become compressed and displaced, leading to frequent urination, digestive blockages and strain in the back muscles. At the end of third trimester the foetus becomes fully developed and ready for parturition.

2.8 Placenta:

It is a flattened, discoidal organ in the uterus of a pregnant woman. The placenta is a temporary structural and functional connection between foetal and maternal circulation. It is attached to the wall of the uterus and to the baby's umbilical cord. The placenta facilitates the supply of oxygen, nutrients, hormones, antibodies and also the removal of carbon dioxide and excretory wastes produced by the foetus.

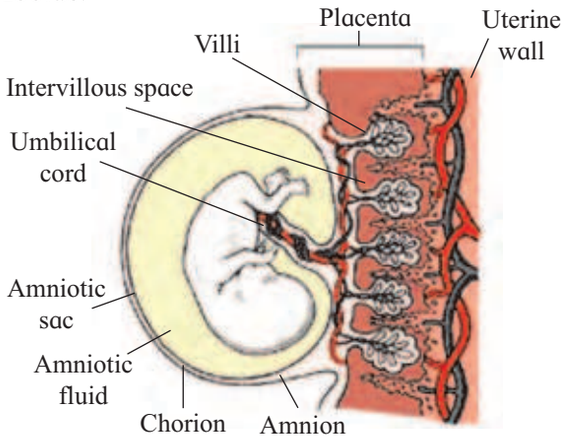


Fig. 2.17 : Placenta

Placenta is the only organ, which is formed of tissues from two different individuals- the mother and the foetus. Part of the placenta contributed by the foetus is called the foetal placenta and it is formed by the **chorionic villi**.

The other part which is rich in blood supply is shared by a part of uterine wall of mother and is termed **maternal placenta**. So human placenta is called **haemochorial**.

The umbilical cord is formed of three blood vessels. Of these three blood vessels, two are small arteries which carry blood towards the placenta and one is a large vein which returns blood to the foetus.

The placenta also acts as an endocrine tissue and produces hormones like hCG, progesterone, estrogen while relaxin is secreted by the ovary in the later phase of pregnancy. Level of hCG increases upto the end of first trimester and then it declines. By the end of first trimester progesterone is produced by placenta. These hormones are required for foetal growth and maintenance of pregnancy.

Know The Institute :

Cord blood bank, Kolkata

India's first Government-run cord blood bank at Kolkata was established in 2001 and is accredited by AABB (American Association of Blood Bank). The cord blood bank functions according to the central and state government policies, rules and guidelines.

Cord blood (umbilical cord blood) is the blood that remains in the umbilical cord and placenta, post delivery. Cord blood banking is the process of collecting the cord blood, extraction and cryogenically preserving for its stem cells and other cells of the immune system for future potential medical use. Cord blood is rich in stem cells that can transform into all sorts of blood cells. They can be used to treat diseases that harm the blood and immune system e.g. leukemia, certain cancers, sickle cell anemia and some metabolic disorders.

Always Remember

hCG, HPL (Human placental Lactogen), relaxin are produced in women only during pregnancy.

2.9 Parturition:

Humans are viviparous, as they give birth to their young ones. Parturition is the process of giving birth to a baby. The physical activities involved in parturition like uterine and abdominal contractions, dilation of cervix and passage of baby are collectively called labour. Labour is accompanied by localised sensation of discomfort or agony called **labour pains**.

Parturition is controlled by a complex neuroendocrine mechanism. Signals arise from the fully formed foetus and placenta cause mild uterine contractions. It is acompanied by rise in estrogen- progesterone ratio, increase in oxytocin receptors in uterine muscles, .

They cause vigorous contractions of myometrium of uterus at the end of pregnancy. The fully developed foetus gives signals for the uterine contractions by secreting Adrenocorticotropic Hormone (ACTH) from pituitary and corticosteroids from adrenal gland. This triggers release of oxytocin from mother's pituitary gland, which acts on uterine muscles of mother and causes vigourous uterine contractions. This leads to expulsion of the baby from the uterus. It involves the following three steps :

1. Dilation stage : Uterine contractions begin from top, forcing the baby towards the cervix. Contractions are accompanied by pain caused by compression of blood vessels. Oxytocin induced uterine contractions become stronger and stronger due to stimulatory reflex. As the baby is pushed down in the uterus, its head comes to lie against cervix. Cervix gets dilated. The vagina also shows similar dilation. This stage of labour can normally last upto few hours. It ends in rupturing of amniotic membrane of foetus.

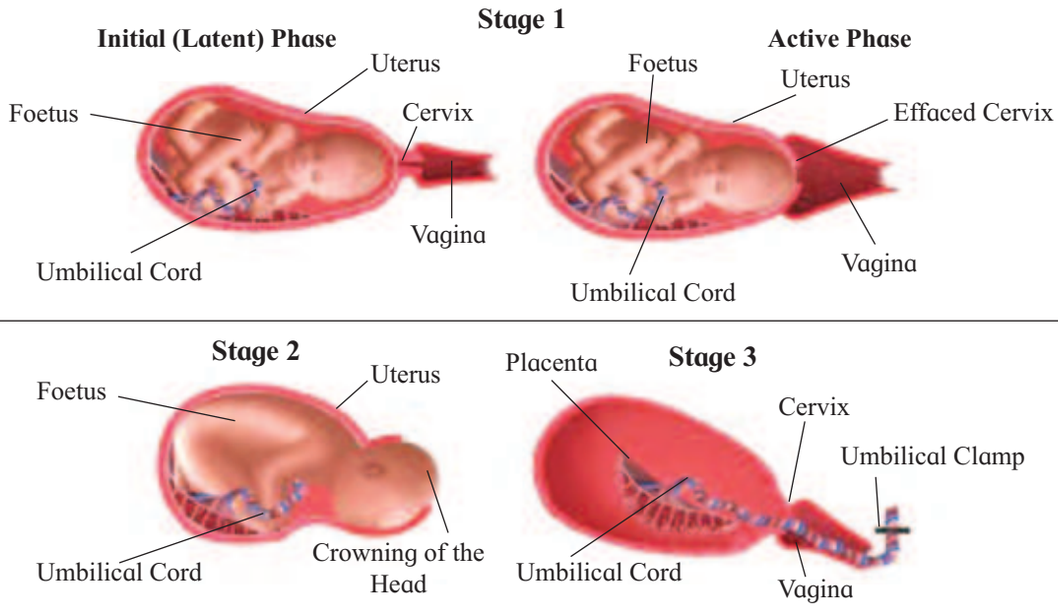


Fig. 2.18 : Parturition

2. Expulsion stage : The uterine and abdominal contractions become stronger. In normal delivery, the foetus passes out through cervix and vagina with head in forward direction. It takes 20 to 60 min. The umbilical cord is tied and cut off close to the baby's navel.

3. After birth : After the delivery of the baby the placenta separates from the uterus and is expelled out as "after birth", due to severe contractions of the uterus. This process happens within 10 to 45 minutes of delivery.

2.10 Lactation:

The mammary glands of the female start producing milk at the end of pregnancy by the process of lactation. Prolactin is the hormone which is responsible for production of milk. Lactation helps the mother in feeding the new born baby. The fluid secreted by the mammary glands soon after child birth is called **colostrum**.

Colostrum: It is the sticky and yellow fluid secreted by the mammary glands soon after child birth. It contains proteins, lactose and mother's antibodies e.g. IgA. The fat content in colostrum is low. The antibodies present in it helps in developing resistance for the new born baby at a time when its own immune response is not fully developed.

Use your brain power

Why is it said that consumption of mother's milk is safest for the new born?

2.11 Reproductive Health:

According to World Health Organisation (WHO), reproductive health means total wellbeing in all aspects of reproduction- its emotional, behavioural and social aspects along with the physical ones. Therefore, a society with people having physically and functionally normal reproductive organs and normal emotional and behavioural interactions amongst them in all sex-related aspects might be called reproductively healthy society.

Of all the social goals of India, an important one is to attain total reproductive health. India was amongst the first few countries in the world to initiate action plans and programmes at a national level to improve reproductive health. All these improved programmes cover wider areas related to reproduction. These programs are currently in operation under the Reproductive and Child Health Care (RCH) programmes.

Goals of RCH Programmes:

1. To create awareness among people about various aspects related to reproduction.
2. To provide the facilities to people to understand and build up reproductive health.
3. To provide support for building up a reproductively healthy society.
4. To bring about a change mainly in three critical health indicators i.e. reducing total infertility rate, infant mortality rate and maternal mortality rate.

The goals of RCH can be achieved by the following ways:

1. By introduction of sex education in schools. Schools should be encouraged to provide correct information to the young so as to discourage children from believing in myths and clear the misconceptions about sex related aspects. Proper information about safe and hygenic sexual practices, sexually transmitted diseases (STD, AIDS), problems related to adolescence and proper information about reproductive organs.
2. With the help of audio- visual and the print media, government and non- government organisations should take various steps to create awareness about various aspects related to reproduction.
3. By educating the younger generation about birth control measures, pre-natal care of pregnant woman and post-natal care of the mother and child, importance of breast feeding.
4. By developing awareness about problems arising due to uncontrolled population growth, social evils like sex abuse and sex related crimes and take up necessary steps to prevent them.
5. By creating awareness about statutory ban on amniocentesis for sex determination.
6. By creating awareness about child immunization programmes.
7. By educating couples to reduce mortality rate of new borns and maternal mortality rate.

The population in India which was approximately 350 millions at the time of independence, reached close to a billion mark by 2000 and crossed 1.2 billion in May 2011. Now in 2020 population of India has crossed 1.35 billions. The government is taking serious measures to check this population growth. The most important step to overcome this problem, is to motivate society to have smaller families by using various birth control methods.

2.12 Birth control :

The birth control measures which deliberately prevent fertilization are referred to as contraceptives. The contraceptive methods help to prevent unwanted pregnancies. An ideal contraceptive should be easily available, user friendly, effective and with no or least side effects.

Contraceptive methods are of two main types i.e. temporary and permanent.

a. Temporary methods:

These are of following types :

1. Natural method/ Safe period / Rhythm method : In the natural method, the principle of avoiding chances of fertilization is used. A week before and a week after menstrual bleeding is considered the safe period for sexual intercourse. This idea is based on the fact that ovulation occurs on the 14th day of menstrual cycle. Its drawback lies in having a high rate of failure.

2. Coitus Interruptus or withdrawal : In this method, the male partner withdraws his penis from the vagina just before ejaculation, so as to avoid insemination. This method also has some drawbacks, as the pre-ejaculation fluid may contain sperms and this can cause fertilization.

3. Lactational amenorrhea (absence of menstruation) : This method is based on the fact that ovulation does not occur during the period

of intense lactation following parturition. Therefore, as long as the mother breastfeeds the child fully, chances of conception are almost negligible. However, this method also has high chances of failure.

4. Chemical means (spermicides): In this method, chemicals like foam, tablets, jellies, and creams are used by the female partner. Before sexual intercourse, if these chemicals are introduced into the vagina, they adhere to the mucous membrane, immobilize and kill the sperms. It may cause allergic reaction. This method also has chances of failure.

5. Mechanical means / Barrier methods: In this method, with the help of barriers the ovum and sperm are prevented from physically meeting. These mechanical barriers are of three types.

i) **Condom:** It is a thin rubber sheath that is used to cover the penis of the male during copulation. It prevents the entry of ejaculated semen into the female reproductive tract. This can prevent conception. It is a simple and effective method and has no side effects. "Nirodh" is the most widely used contraceptive by males. It is easily available and is given free by the government. It should be properly discarded after every use. Condom is also a safeguard against STDs and AIDS.

ii) **Diaphragm, cervical caps and vaults:** These devices used by the female are made up of rubber. They prevent conception by blocking the entry of sperms through the cervix. The device is inserted into the female reproductive tract to cover the cervix during copulation.

iii) **Intra-uterine devices (IUDs) :** These clinical devices are plastic or metal objects. A doctor or trained nurse places the IUDs into the uterus. These devices include Lippes loop, copper releasing IUDs (Cu-T, Cu7, multiload 375) and hormone releasing IUDs (LNG-20, progestasert).

Diaphragm

Lippes loop

Fig. 2.19 : Mechanical means

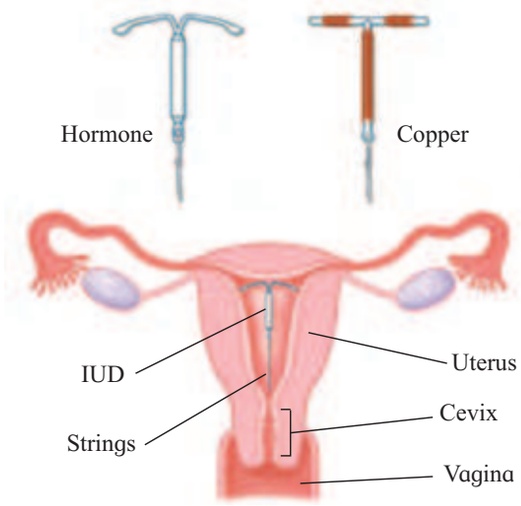


Fig. 2.20 : Copper - T

Lippes loop is a plastic double "s" loop. It attracts the macrophages stimulating them to accumulate in the uterine cavity. Macrophages increase phagocytosis of sperms within the uterus and acts as a contraceptive. Copper releasing IUDs suppress sperm motility and the fertilizing capacity of sperms.

The hormone releasing IUDs make the uterus unsuitable for implantation and cervix hostile to the sperms. It delays pregnancy for longer period. The spontaneous expulsion, occasional haemorrhage and chances of infection are the drawbacks of IUDs.

6. Physiological (Oral) Devices : Physiological devices are used in the form of tablets and hence are popularly called **pills**. It is an oral contraceptive, used by the female. The pill contains progesteron and estrogen. They inhibit ovulation, hence no eggs are released from the ovary of the female using this pill and thus conception cannot occur. They also alter the quality of cervical mucus to prevent the entry of sperms.

The pills have side effects such as nausea, weight gain, tenderness of breast and slight blood loss between menstrual periods. The pill "**Saheli**" is an oral contraceptive for females which is nonsteroidal. Saheli is to be taken once in a week. These pills are sponsored by the Government.

Always Remember

Saheli is now a part of the National Family Programme as an oral contraceptive pill in India.

7. Other contraceptives : The birth control **implant** is a contraceptive used by the female. It is a tiny, thin rod about the size of a matchstick. It is implanted under the skin of the upper arm.

They contain progesterone and estrogen. Their mode of action is similar to that of pills. They prevent pregnancy for 3-4 years.

Fig. 2.21 : Implanon/ Nexplanon

b. Permanent Method:

The permanent birth control method in men is called vasectomy and in women it is called tubectomy.

These are surgical methods, also called sterilization. In vasectomy a small part of the vas deferens is tied and cut where as in tubectomy, a small part of the fallopian tube is tied and cut. This blocks, gamete transport and prevent pregnancy.

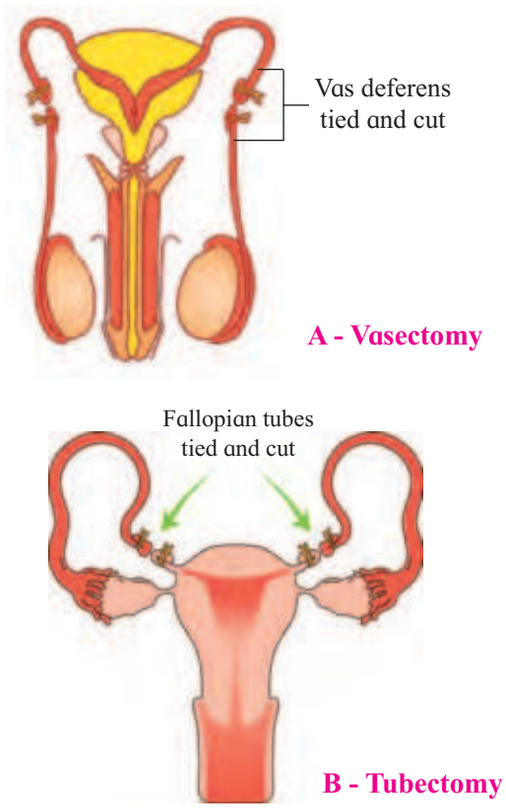


Fig. 2.22 : Permanent method

Medical Termination of Pregnancy (MTP) :

An intentional or voluntary termination of pregnancy before full term is called Medical termination of Pregnancy (MTP) or induced abortion. MTP is essential in cases of unwanted pregnancies or in defective development of foetus. It is safe during the first trimester of pregnancy. The defective development of foetus is examined by amniocentesis.

Amniocentesis is a process in which amniotic fluid containing foetal cells is collected using a hollow needle inserted into the uterus under ultrasound guidance. The chromosomes are studied to see the abnormalities in the developing foetus. But the dangerous trend is the misuse of amniocentesis to determine the sex of the unborn child. Frequently, if the foetus is found to be female, it is aborted which is totally illegal. So the Government of India has legalised MTP Act in 1971, with strict conditions to avoid its misuse.

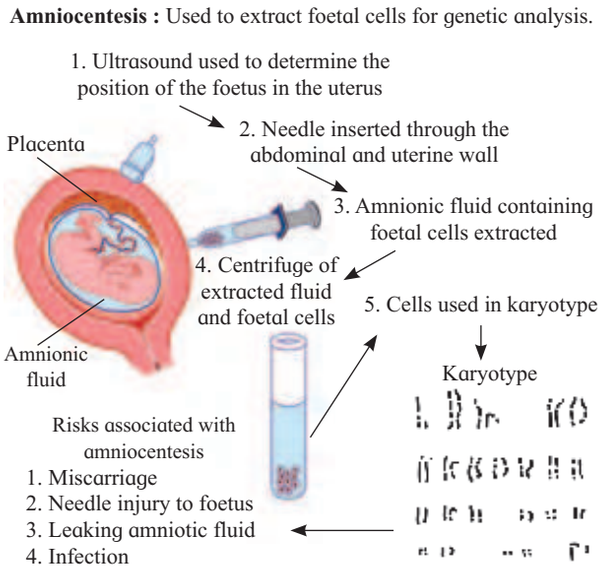


Fig. 2.23 : Amniocentesis process

Always Remember

Act of MTP : The Medical Termination of Pregnancy (MTP) Act 1971 provides the legal framework for MTP Act 2017.

Activity :

In a sonography clinic, we observe a board saying 'Sex selection and detection is NOT done in this centre and is punishable under PC-PNDT Act;

Find out what is PC-PNDT Act. Why do you think such a mandate is essential?

Medical Termination of Pregnancy (Amendment) Act 2017 under section 3 of the MTP Act 1971 was enacted by Government of India. The intention of MTP Act is to reduce the incidence of illegal abortion and consequent maternal mortality. As per the provisions of the MTP Act, only the consent of woman whose pregnancy is being terminated is required. According to MTP Act pregnancy may be terminated : 1. Within first 12 weeks 2. More than 12 weeks but lesser than 20 weeks. The registered medical practitioner's opinion is mandatory stating the continuation of the pregnancy would involve a risk to the life of the pregnant woman or grave abnormal physical or mental health or is substantial risk to the child.

Internet my friend

What are the effects of alcohol drinking and smoking on foetus in pregnant women?

2.13 Sexually Transmitted Diseases (STDs) :

Diseases or infections which are transmitted through sexual intercourse are collectively called Sexually Transmitted Diseases (STDs) or Venereal Diseases (VDs) or Reproductive Tract Infections (RTI). The major venereal diseases are syphilis and gonorrhoea.

Internet my friend

Collect information about other sexually transmitted diseases.

Table 2.24 : Sexually Transmitted Diseases (STDs)

Name of Disease	Syphilis	Gonorrhoea
Causative agent	*Treponema pallidum* (Bacteria)	*Neisseria gonorrhoeae* (Bacteria)
Incubation period	3-4 weeks	Male – 2 to 14 days Female – 7 to 21 days
Infection site	Mucous membrane in genital, rectal and oral region.	Mucous membrane of urino-genital tract, rectum, throat and eye.
Symptoms	Primary lesion called **chancre** at the site of infection. Chancre is formed on external genitalia, skin rashes and mild fever, inflamed joints, loss of hair. Paralysis, Degenerative changes occur in the heart and brain.	In male, partial blockage of urethra and reproductive ducts, pus from penis, pain and burning sensation during urination, arthritis, etc. In female, pelvic inflammation of urinary tract, sterility, arthritis, the children born to affected mother suffer from gonococcal opthalmia and gonococcal vulvovaginitis of girls before puberty.
Preventive measures	Education about sex practices, sex hygiene, avoiding sex with unknown partner or multipartners, using condom during coitus.	Sex hygiene, using condom during coitus, avoiding sex with unknown partner or multipartners.
Treatment	Antibiotic-Penicillin	Antibiotic-Cefixime

2.14 Infertility :

Infertility is defined as the inability to conceive naturally after (one year of) regular unprotected intercourse. The causes of infertility could be physical, congenital, diseases, immunological or even psychological. The common physical causes in females are polycystic ovary syndrome (PCOS), hormonal imbalance, endometriosis while in male, it is less sperm count and small size of penis.

Prior to 1978, infertile couple had two options, adopt or be childless. Today infertile couples have many options to have a child such as fertility drugs, test tube babies, artificial insemination, IUI, surrogate motherhood, etc. The couple could be assisted to have child / children through certain special techniques commonly known as Assisted Reproductive Technologies (ART).

IVF (In Vitro Fertization) :

It is a process of fertization where an egg is combined with sperm outside the body in a test tube or glass plate to form a zygote under simulated conditions in the laboratory. The zygote or early embryos (with up to 8 blastomeres) could be then transferred into the fallopian tube for further development.

ZIFT (Zygote Intrafallopian Transfer) :

ZIFT is an infertility treatment used when there is a blockage in the fallopian tubes which prevents the fertilization of egg by the sperm.

In this method, egg is removed from woman's ovary. Fertilization of the egg with sperms is brought about outside the body under sterile conditions to form zygote by the process called *in vitro* fertilization (IVF). The zygote is then transferred to fallopian tube for further development.

Try This

IVF centres : Make a list of IVF centres in Maharashtra.

GIFT (Gamete Intrafallopian Transfer) :

Transfer of an ovum collected from a donor into the fallopian tube of another female who can provide suitable environment for its fertilization and development.

This technique called gamete intrafallopian transfer (GIFT) has been developed for the cases in which only the entrance to the oviducts or the upper segment of the oviducts in blocked. In this procedure ova and sperms are directly injected into regions of the oviduct, where fertilization produces a blastocyst, which enters the uterus via the normal route. GIFT has a success rate of about 30 percent.

ICSI (Intra Cytoplasmic Sperm Injection) :

ICSI is an *in vitro* fertilization procedure in which a single sperm cell is injected directly into cytoplasm of an ovum in the laboratory. Here the sperm has to naturally penetrate the egg.

Artificial Insemination (AI) :

In some infertility cases, the male partner is unable to inseminate the female due to a very low sperm count. This problem can be solved by artificial insemination. In this technique, the sperms are collected from the male and artificially introduced into the cervix of female, for the purpose of achieving a pregnancy through *in vivo* fertilization (inside the body).

IUI (Intra Uterine Insemination) :

In this technique the process is somewhat like that of artificial insemination, the only difference is that the sperms are introduced into the uterine cavity instead of cervix.

Sperm bank / Semen bank:

A sperm bank or semen bank is a place which collects, stores and provides human sperms / semen. The semen is provided by healthy males called **sperm donors**. The sperms are stored in sperm bank by cryopreservation method (at low temperature).

Can you recall?

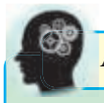
Surrogate mother :

Some women have problem in implantation of embryo in uterus. Such woman can take help of the modern remedial technique called surrogacy. In this, embryo is implanted in surrogate mother, who is not the biological mother.

Adoption :

Adoption is a legal process by which a couple or a single parent gets legal rights, privileges and responsibilities that are associated to a biological child for the upbringing of the adopted child.

An adoptive parent should be medically fit and financially able to take care of the adopted child. A person wishing to adopt a child must be at least 21 years old but there is no legal upper age limit for adoption.



Always Remember

Tobacco, marijuana and other drugs smoking may cause infertility in both men and women. Nicotine blocks the production of sperm and decreases the size of testicles. Alcoholism by men interferes with the synthesis of testosterone and has an impact on sperm count. Use of cocaine or marijuana may temporarily reduce the number and quality of sperm.

Can you tell?

- Jayesh, a young married man of 26 yrs is suffering from T. B. for the last 2 years. He and his wife are desirous of a child but unable to have one, what could be the possible reason? Explain.
- Neeta is 45 years old and the doctor has advised her not to go for such a late pregnancy. She however wants to be the biological mother of a child, without herself getting pregnant. is this possible and how?

Always Remember

1. Cells of trophoblast do not form any part of the embryo proper.
2. They form ectoderm of the chorion (extra embryonic membrane).
3. They play important role in formation of placenta.

Activity :

1. Prepare concept map on information of male reproductive system.

2. Prepare concept map on information of female reproductive system.

Activity :

3. Prepare concept map on information of menstrual cycle.

4. Prepare concept maps on information of gametogenesis.

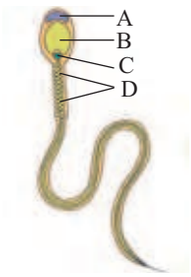
Spermatogenesis **Oogenesis**

5. Prepare concept map on information of fertilization.

Exercise

Q. 1 Multiple choice questions.

1. The number of nuclei present in a zygote is ……
   a. two b.one c. four c.eight
2. Which of these is the male reproductive organ in human?
   a. sperm b. seminal fluid
   c. testes d. ovary
3. Attachment of embryo to the wall of the uterus is known as……..
   a. fertilization b. gestation
   c. cleavage d. implantation
4. Rupturing of follicles and discharge of ova is known as .....
   a. capacitation b. gestation
   c. ovulation d. copulation
5. In human female, the fertilized egg gets implanted in uterus .....
   a. After about7 days of fertilization
   b. After about 30 days of fertilization
   c. After about two months of fertilization
   d. After about 3 weeks of fertilization
6. Test tube baby technique is called.....
   a. In vivo fertilization
   b. In situ fertilization
   c. In vitro fertilization
   d. Artificial insemination
7. The given figure shows a human sperm. Various parts of it are labelled as A, B, C, and D .Which labelled part represents acrosome ?



   a. B b. C c. D d. A
8. Presence of beard in boys is a .....
   a. primary sex organ
   b. secondary sexual character
   c. secondary sex organ
   d. primary sexual character

Q. 2 Answer in one sentence.

1. What is the difference between a foetus and an embryo?
2. Outline the path of sperm upto the urethra.
3. Which glands contribute fluids to the semen?
4. Name the endocrine glands involved in maintaining the sex characteristics of males.
5. Where does fertilization and implantation occur?
6. Enlist the external genital organs in female.
7. Give two differences between blastula and gastrula.
8. What is the difference between embryo and zygote?

Q. 3 Fill in the blanks:

1. The primary sex organ in human male is …….
2. The……. is also called the womb.
3. Sperm fertilizes ovum in the …….. of fallopian tube.
4. The disc like structure which helps in the transfer of substances to and from the foetus's body is called……
5. Gonorrhoea is caused by …… bacteria.
6. The hormone produced by the testis is ……..

Q. 4 Short answer questions.

1. Write a note on budding in *Hydra.*
2. Explain the different methods of reproduction occuring in sponges.
3. Write a note on IVF
4. Comment on any two mechanical contraceptive methods.
5. Write a note on tubectomy
6. Give the name of causal organism of **syphilis** and write on its symptoms.
7. What is colostrum?

Q. 5 Answer the following questions.

1. Describe the phases of menstrual cycle and their hormonal control.
2. Explain the steps of parturition.
3. Explain the histological structure of testis.
4. Describe the structure of blastula.
5. Explain the histological structure of ovary in human.
6. Describe the various methods of birth control to avoid pregnancy.
7. What are the goals of RCH programme.
8. Which hormones are involved in parturition?
9. Which as the function of male accessory glands?
10. What is capacitation? Give it's importance.

Q. 6 Long answer questions.

1. Explain the following parts of male reproductive system along with labelled diagram showing these parts- Testis, vasa deferentia, epididymis, seminal vesicle, proastate gland and penis.
2. Describe female reproductive system of human.
3. Describe the process of fertilization.
4. Explain the process by which zygote divides and redivides to form the morula.

Project :

Prepare a chart showing information about other STDs, mentioning causal organisms, symptoms and control measures.