HUMAN REPRODUCTION

To continue its own race, an organism by the process of reproduction, produces offsprings like its own. In sexual reproduction the organisms produce male and female gametes which on combining, develop into a new individual. The formation of gametes takes place in the reproductive organs.

Embryology is the branch of biology which deals with the study of all those processes, which take place during development of foetus.

Primary sex organ :

Essential organs which form the gametes. In males, the gamete forming organs are the **testes**. In females, the corresponding organs are **ovaries**.

The male gamete is spermatozoon. The female gamete is ovum.

Secondary sex organ :

These organs form the passage for the gametes to help the union of male & female gametes.

In male these include epididymis, vas deferens, seminal vesicles, prostate, bulbourethral glands & penis etc.

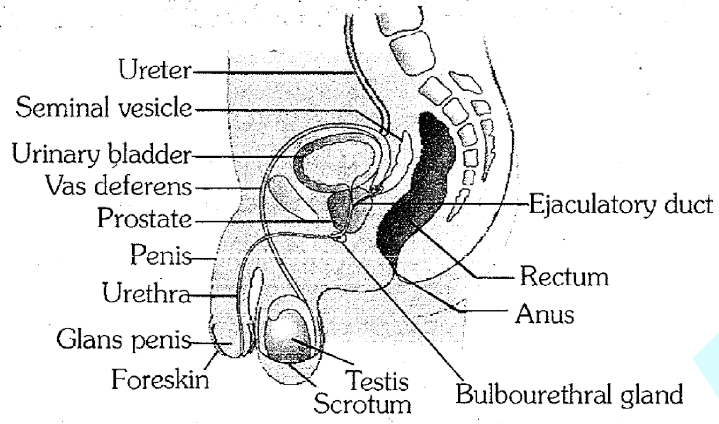
In female these organs are fallopian tube, uterus and vagina, bartholin gland etc.

Development of Sex organ :

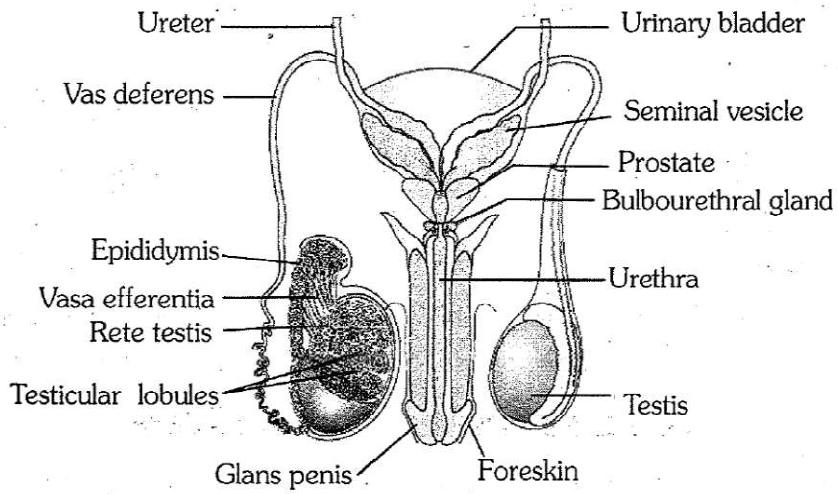
During intra uterine life (IUL) testis & ovary develop from mesoderm. They develop in abdominal cavity. At the time of birth, testes descend down into scrotal sac but ovaries remain in abdominal cavity.

MALE REPRODUCTIVE SYSTEM

- In man, one pair testes are the main or primary reproductive organ. Size 4-5 cm × 2-3 cm
- Both testes are located in a small bag like structure situated below & out side the abdominal cavity called as scrotum or scrotal sac. The temperature of scrotum is 2 – 2.5ºC lesser than body temperature.
- Internally scrotum is lined by **dartos muscle** and **spermatic fascia**.
  Dartos muscle helps in regulation of the temperature with in the scrotum during cold season,
  It becomes contracted in cold & during warm season, it becomes relaxed.
  Cremaster muscles line inside the wall of scrotal & inguinal canal region and help in elevation of testes.
- Each testis is attached to the walls of the scrotal-sac through flexible, elastic fibres. This group of fibres is called Gubernaculum or Mesorchium.
- Each testis is attached to the dorsal body wall of the abdominal-cavity through a cord termed as the **Spermaticcord**. This cord is made up of elastin fibres & spermatic fascia. The contents of cord are vas deferens, gonadal veins, gonadal arteries, nerves and lymphatics.
  During embryonic stage, testes develop in abdominal cavity & they descend to reach the scrotum at the time of birth. When the testes does not descend to reach the scrotum but remain in abdominal cavity at the time of birth this conditions is called **undescended testes** or **cryptorchidism**. Such testis can not develop and function properly and may develop malignancy.
- Scrotum is connected to the abdominal cavity through a passage termed as inguinal-canal. Through this canal the testis descend down into the scrotal-sacs at the time of birth.
  Spermatic cord in males passes through the. inguinal canal.



Diagrammatic sectional view of male pelvis showing reproductive system



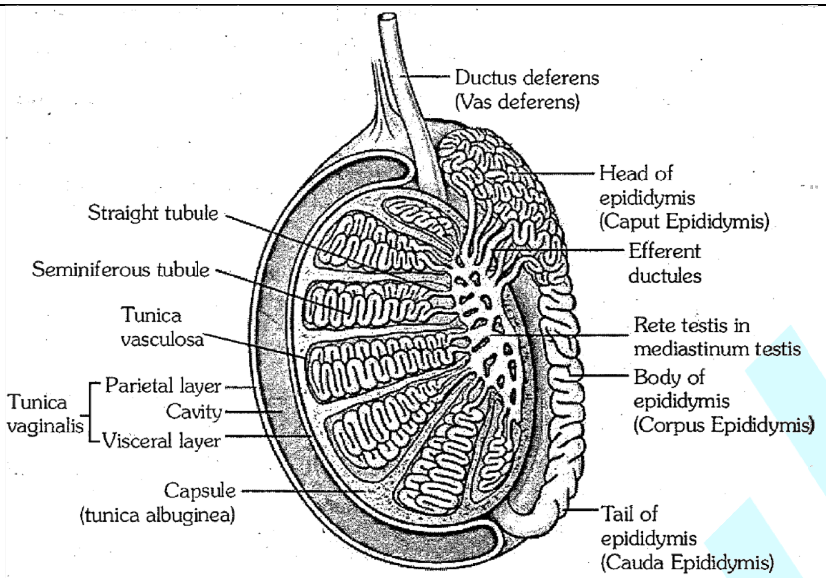
Diagrammatic view of male reproductive system (part of testis is open to show inner details)

Internal Structure of Testis :

Testis is covered by three coats. Outer most is tunica vaginalis. Middle coat is tunica albuginea & inner most is tunica vasculosa.

Tunica vaginalis has a parietal & visceral layer. It covers the whole testis except it's posterior border from where the testicular vessels & nerves enter the testis.

The **Tunica albuginea** is a dense, white fibrous coat covering the testis all around. The posterior border tunica albuginea is thickened to form vertical septum called the **Mediastinum testis.**



Structure of testis

Tunica vasculosa is the inner most vascular coat of the testis lining testicular lobules.
Each lobules has 1 to 3 seminiferous tubules, which join together at the apices of the lobules to form straight tubules or tubuli recti which enter the dediastinum.

Here they form a network of tubules called as **rete testis**. Rete testis fuse to form 10 to 20 efferent ductile called as **vasa efferentia or ductuli efferentes**. These ductules come out from upper dorsal (posterior) surface of testis & open into common tubules, which get highly coiled to form epididymis or ductus epididymis. This epididymis is responsible for functional maturation of sperm.

- Total number of seminiferous tubules in each testis is about 750 to 1000.

Epididymis has 3 parts :
In man it is 6m in length.

(i) **Upper, highly coiled part** – Caput epididymis or Globus-major
(ii) **Middle part** – Corpus epididymis
(iii) **Basal, least coiled part** – Cauda epididymis or Globus minor

Cauda-epididymis enters inside the abdominal-cavity from the scrotal-sac in the form of **vas deferens** or ductus deferens. Terminal dilated part of vas deferens are called **ampulla**. Vas deferens and epididymis both develop from the **wolffian-duct** of **mesonephros. Epididymis can temporarily stores the sperms for as long as one month and here the functional·maturation of spem1s takes place.**
The wall of epididymis is made up of 2 layers-outer circular muscle layer and inner epithelium. Wall of vasdeferens is also made up of 2 layers-outer circular muscle layer and epithelium. The sperms reach the abdominal cavity due to the pulsation of the vas-deferens.
Vas deferens runs upward and enter into abdominal cavity. Both vas deferens coil around the ureter of their respective sides and then dilate to form ampulla. Ampulla of Vas deferens of each side receives the seminal. vesicle of that side. The vas deferens now forms ejaculatory duct and opens into prostatic urethra.
1 pair of seminal vesicles are situated on dorso lateral side of urinary bladder which open seperately before the terminal ends of vas deferens. So terminal ends of vas deferens meet to form a single ejaculatory duct in each side.

Accessory Reproductive Glands

The substances secreted by the accessory reproductive glands do not form gametes but help in reproduction, these are-

1. Seminal vesicle

It is formed from the Wolffian duct of the embryo. Internally, it is lined by glandular epithelium which secretes seminal fluid. This is lubricating, transparent and jelly like substance, which **makes 60-70% part of semen**.

It is slightly alkaline (pH 7.3). **Fructose** is found in seminal fluid, it act as fuel to sperm. Fibrinogen, prostaglandin, citrate, inositol and several proteins are also present in semen.

2. Prostate gland

This gland is located below the urinary bladder. It is unpaired and made up of 5 lobes in man. Each lobe opens into prostatic urethra through many fine apertures. It secretes slightly alkaline prostatic fluid which is milky, thick, sticky or jelly like. It makes about **30% part of semen** and helps in sperm activation.

The secretion of prostate gland has citric acid, calcium and phosphate, clotting enzyme and profibrinolysin are present. The secretion of the prostate gland combines with the secretion of seminal vesicle and so the semen gets coagulated. In the coagulated semen, the mobility of sperms is reduced and so their energy is conserved. After some time due to fibrinolysins, semen again liquefies and in this semen now the sperms can move.

3. Cowper's glands

It is a pair of glands found on lateral side of urethra. It is also called as **bulbourethral gland**. It is situated in membranous part of urethra & opens into penile urethra. It secretes transparent, slimy, jelly like fluid. It is slightly alkaline (pH is 7.2). This destroys the acidity of the urethra and cleans it for the movement of sperms.

It also helps in the lubrication of the penis.

Semen -

Semen = Sperm + Accessory reproductive gland fluid
Volume = 3 to 4 ml.
pH = 7.3
Normal sperm count 20 to 120 million / ml.
Oligospermia < 20 million / ml.
Azospermia – either absence or near absence of sperms.
Asthenospermia – Reduced motility of sperms in semen
Teratospermia – sperms with abnormal morphology

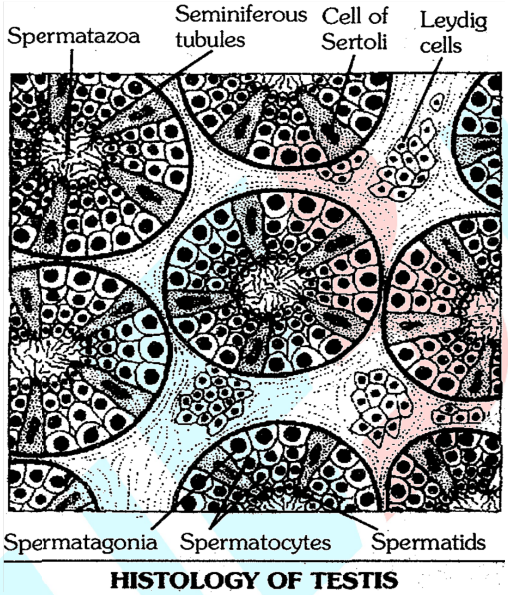
The human male ejaculates about 200 to 300 million sperms during a coitus of which, for normal fertility, at least 60 percent sperms must have normal shape and size and for at least 40 percent of them must show vigorous motility.

Histology of seminiferous Tubules :

Outer surface of seminiferous tubules is composed of white fibrous connective tissues called as **tunica propria** while inner surface is of **cuboidal germinal epithelium**. This epithelium is made of spermatogenic cells which forms sperm by spermatogenesis. Some columnar cells are found in the layer of germinal epithelium ill called as **Sertoli cells**. These provide mitrition to germ cells, so they are also called as **sustentacular** or **nurse cells** (these occur in mammals).

Other function of Sertoli cells -

(1) They phagocyte the injured or dead sperm cells
(2) They are the basis of blood testis barrier
(3) Sertoli cells produce inhibin and antimullerian hormone.
(4) Sertoli cells can synthesize estrogen from testosterone. FSH acts on the Sertoli cells and stimulates secretion of some factors which help in the process of spermiogenesis. Some factors which help in the process of spermiogenesis. Some endocrine cells are found between seminiferous tubules in intertubular space, these are called as **interstitial or Leydig cells**. These cells secrete **androgens (testosterone).** The testosterone from Leydig's cells enter the seminiferous tubules by diffusion under the effect of ABP & promotes spermatogenesis. Leydig cells synthesise and secrete testicular hormones called androgens. Other immunologically competent cells are also present.



HISTOLOGY OF TESTIS

Penis

The penis is the male external genitalia, made up of special tissue (Erectile tissue).
Urethra continues in a muscular and tubular organ called as **penis**. Terminal part of shaft of penis is bulging, it is called as Glans penis. This glans penis is covered by a loose fold of skin called as **prepuce or foreskin**. A special type of sebaceous gland is found on the prepuce called **preputial gland** which secretes **smegma**.
Removal of prepuce by surgery is called is **circumcision**.
Prepuce is attached to the base of glans with the help of an elastic cord like membrane called **frenulum prepuce**.
Penis is an erectile copulatory intromittent organ (Organ of copulation). Root of the penis containing muscles is called crura. Penis consists of a long shaft that enlarges to form an expanded tip called the glans penis.

Body of Penis :

It is composed of three longitudinal cylindrical masses of erectile tissue. These masses are, the right and left corpora cavernosa and a median corpus spongiosum.
The two corpora cavernosa do not reach the end of the penis. Each of them terminates under cover of the glans penis,

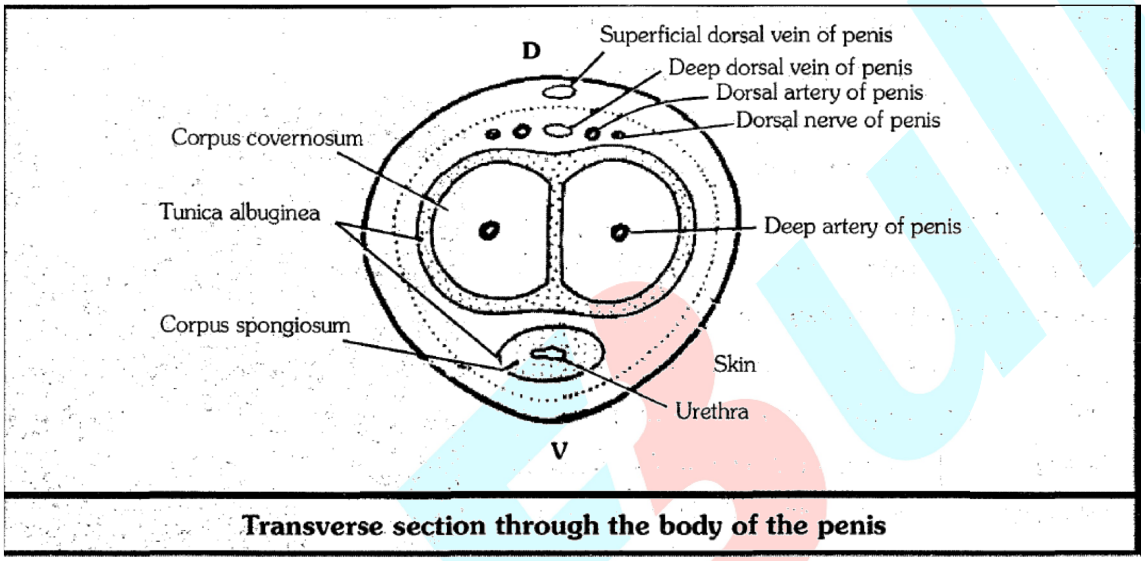
The corpus spongiosum continues further, its terminal part is expanded to form a conical enlargement called the **glans penis**. Through out its whole length it is traversed by the **urethra.**

External opening of penis is called penile/urethral meatus.

Erection of Penis :

Erection of penis is purely vascular phenomenon and is controlled by A.N.S. It occurs due to increase of blood supply, due to dilation of penile arteries causing enlargement and hardening of penis.

During this time the muscles of crura are relaxed.



Transverse section through the body of the penis

GOLDEN KEY POINTS

- **Orchiopexy :** When the undescended testes are brought into scrotal sac by surgical process during childhood this process called as orchiopexy.
- Cutting of the vasa-deferens and ligation is termed as **vasectomy**.
- Erection of penis is controlled by parasympathetic nervous system.
- Ejaculation of semen is controlled by sympathetic nervous system.

BEGINNER'S BOX-1

MALE REPRODUCTIVE SYSTEM

1. Partitions of testis develop from
(1) Tunica albuginea (2) Tunica vasculosa
(3) Tunica vaginalis (4) Rete testis

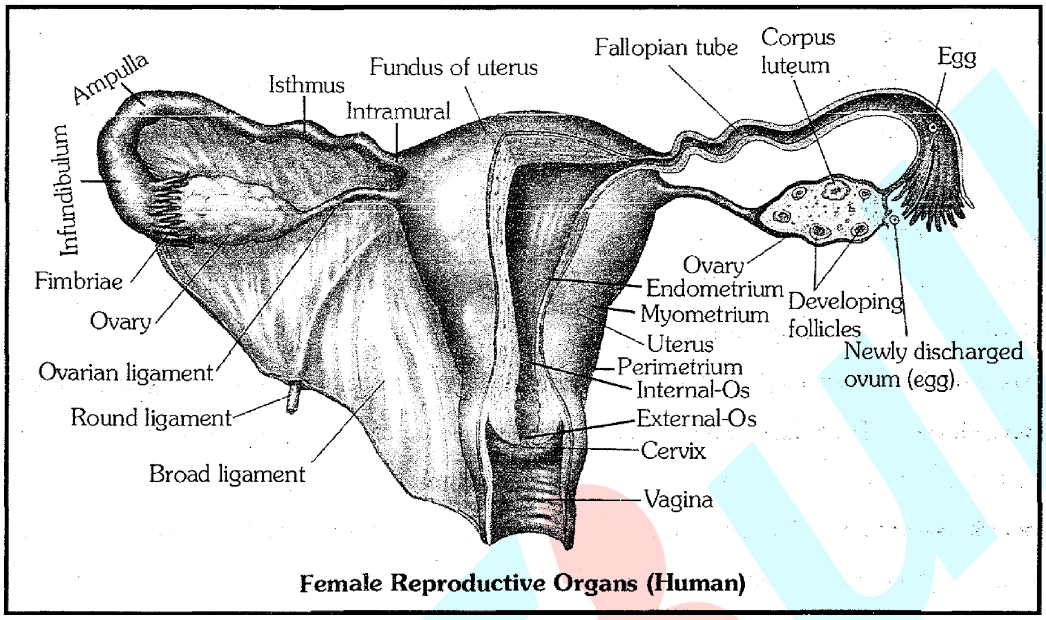
2. Vas deferens arises from
(1) Cauda epididymis (2) Caput epididymis
(3) Corpus epididymis (4) Rete testis

3. Testosterone is secreted by the
(1) Leydig's cells (2) Sertoli cells
(3) Pituitary gland (4) Testis

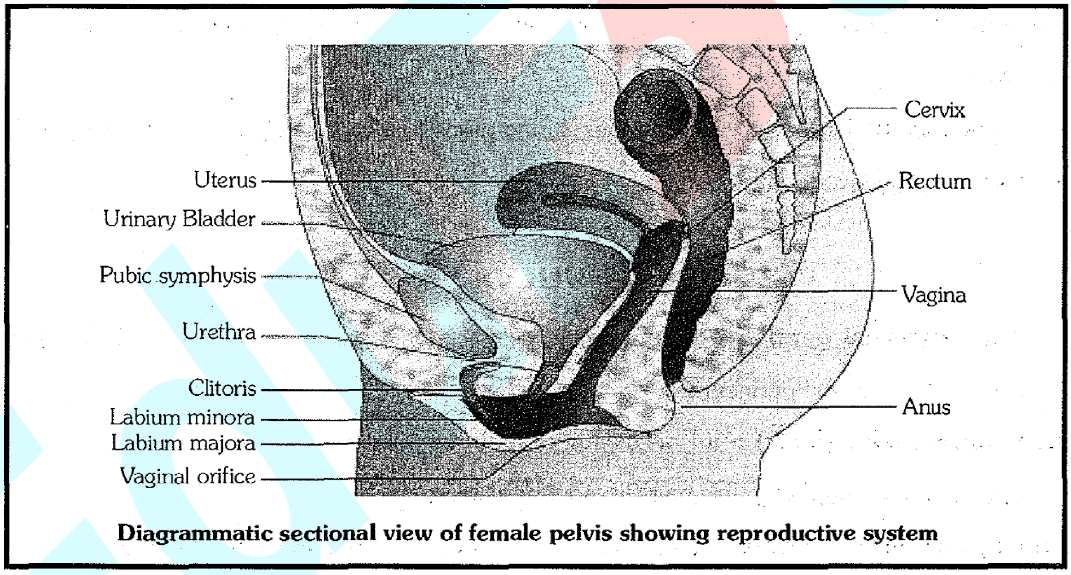
4. In between spermatogonia are found
(1) Germinal cells (2) Sertoli cells
(3) Epithelial cell (4) Lymphatic space

FEMALE REPRODUCTIVE SYSTEM

A pair of ovaries is the main or primary sex organ of female reproductive system. Both ovaries are located in abdominal cavity.



Female Reproductive Organs (Human)



Diagrammatic sectional view of female pelvis showing reproductive system

Female secondary sex organs are 1 pair fallopian tube, 1 uterus and 1 vagina and 1 pair Bartholin glands. The lateral end of fallopian tube. which closer to the ovary is funnel shaped and called as **infundibulum**. Its fimbriated and terminal end bears aperture called as **abdominal ostium** which opens into peritoneal cavity. Fimbriae help in collection of the ovum after ovulation. The part medial to the infundibulum is called **ampulla**, it is a thin walled dilated part of tube. Fertilization takes place in the ampulla. The part medial to ampulla is called isthmus. The most medial part of this tube situated in the uterus is called **intramural or interstitial part of tube**. During ovulation, the ova are released in the peritoneal cavity, due to this it is called **coelomic egg.**

- Simplex type of uterus present in human.

- It is the most developed form of the uterus which is made from the complete fusion of both uterus.
  It is piriform (inverted pear) shape, the upper expanded part is called as body or fundus while lower cylindrical part is called as **cervix**.
  The cavity of cervix is called cervical canal. Which along with vagina forms the birth canal.
  On internal surface of cervix 2 types of constrictions are found which form the **Os-cervix**.
  The body of uterus communicates. with the cervix through opening called **internal Os.**
  The cervix communicates with the vagina through an opening called **external Os**.
  The uterus open into a fibromuscular & non glandular tube like organ called **vagina** (Copulatory organ).

Histology of uterus and fallopian tube :

I. **Serosa or the adventitia :-** It is the outermost thin layer of visceral-peritoneum **(Perimetrium)**

II. **Muscle-layer :-** The middle layer of the oviduct is made up of unstripped-muscle. In uterus, thick smooth muscle bundles are found, these are called as **myometrium**.

III. **Mucous membrane :-** It is the innermost layer. Mucosa consists of simple columnar epithelium. Epithelium contains both ciliated cells and secretory cells. The secretory cells produce viscous liquid film that provides nutrition and protects the ovum. Mucosa of uterus is called **endometrium (glandular layer),** it contains simple - branched tubular glands, many fibroblasts and blood vessels. In the uterus, the embryo is attached to endometrium.

- The endometrium undergoes cyclical changes during menstrual cycle while the myometrium exhibits strong contraction during delivery of the baby.

VULVA

Vulva means **external genitalia of female**. It include mons veneri,. Labia majora, labia minora, clitoris, hymen, vestibule & related perineum.

Mons veneris (mons pubis) :- It is a cushion of fatty tissue or of subcutaneous connective tissue, lying in front of pubis & is covered by pubic hairs in adult female.

Labia majora :- Vulva is· bounded on each side by the elevation and fleshy folds of skin & subcutaneous tissue.
Its inner surface is hairless.
Outer surface is covered by sebaceous gland, Sweat gland & hair follicles. It is homologous with the scrotum in the male.

Labia minora :- They are two thin folds of skin present just within the labia majora. Lower portion of minora fuses across the midline & form a fold of skin called **fourchette**.

Clitoris :- It is a tiny finger - like structure which lies at the upper junction of the two labia minora above the yrethral opening. It is made up of two erectile bodies (corpora cavernosa). The skin which covers the glans of clitoris is called **prepuce**.

At the terminal part of vagina the urethra opens separately, so they form a common chamber called **vaginal vestibule or urino genital sinus.**
The vulva has following openings:-

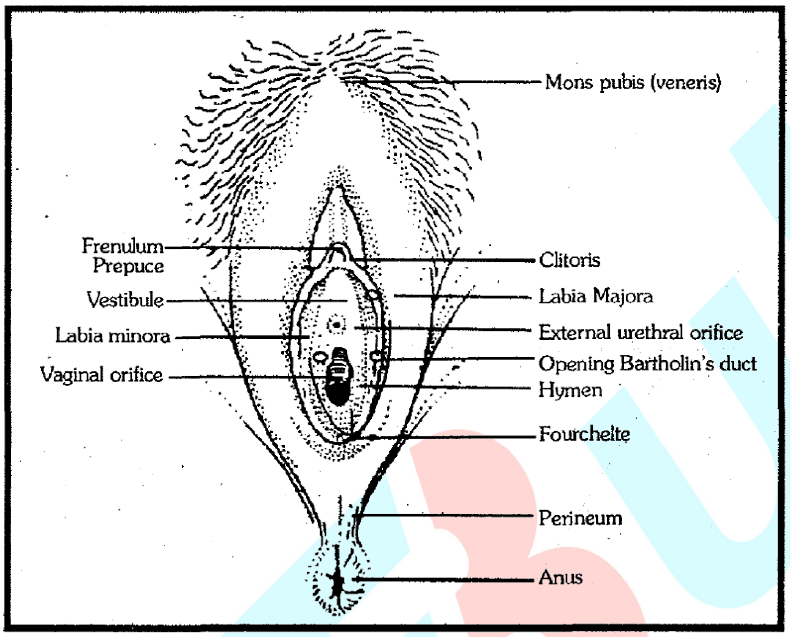
(a) Urethral opening - Lies on anterior end

(b) Vaginal orifice- Lies on posterior end.
It is incompletely closed by a septum of mucous membrane called hymen, but it may not be a true sign of virginity. The hymen is often torn during the first coitus (intercourse). However. it can also be broken by a sudden fall or jolt, insertion of a vaginal tampon, active participation in some sports like horseback riding, cycling, etc.

In some women the hymen persists even after coitus. In fact. the presence or absence of hymen is not a reliable indicator of virgin@ or sexual experience.

(c) Opening of bartholin's ducts :

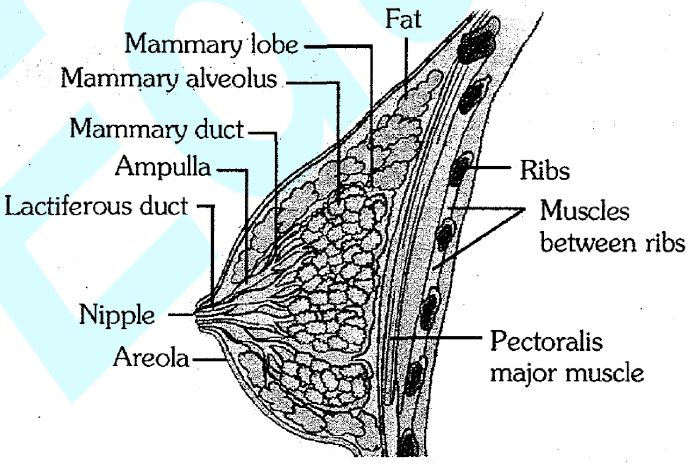
These are opening of one pair bartholin's /greater vestibular glands situated on lateral side of vagina. Th!aY secrete alkaline fluid during sexual excitement.



BREAST

The mammary glands are paired structures (breasts) that contain glandular tissue and variable amount of fat.

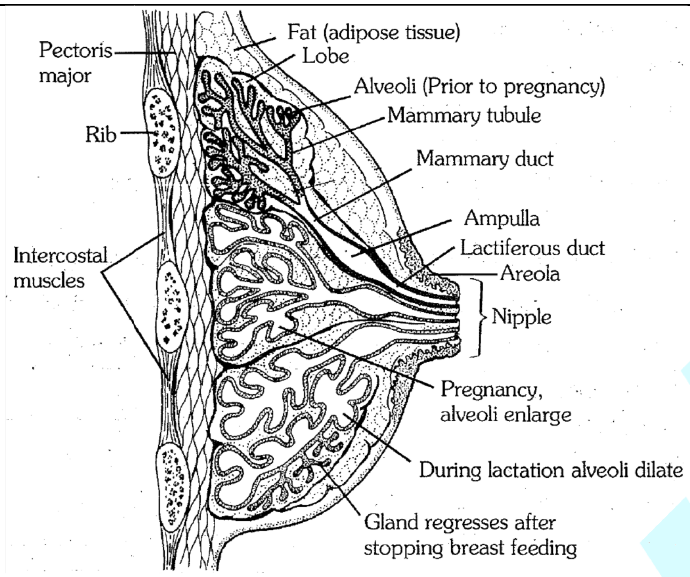
The glandular tissue of each breast is divided into 15-20 **mammary lobes** containing clusters of cells called alveoli (Figure). The cells of alveoli secrete milk, which is stored in the cavities (lumens) of alveoli. The alveoli open into mammary tubules. The tubules of each lobe join to form a **mammary duct.** Several mammary ducts join to form a wider mammary ampulla which is connected to **lactiferous duct** through which milk is sucked out.



A diagrammatic sectional view of Mammary gland

Structure of a Lobe

Many alveoli or acini
↓
Many mammary tubules
↓
Many mammary ducts
↓
One mammary ampulla
↓
One lactiferous duct which opens on surface of nipple



Mammary glands produce a nutritive fluid, milk for the nourishment of young ones. Milk protects the young ones from various infections upto some months after birth

The mammary glands of the female undergo differentiation during pregnancy and starts producing milk towards the end of pregnancy by the process called **lactation**. This helps the mother in feeding the newborn. Breastfeeding during the initial period of infant growth is recommended by doctors for bringing up a healthy baby.

GOLDEN KEY POINTS

- Uterus also called womb.
- Longest unstripped muscles of the body are found in the walls of uterus. (During pregnancy)
- Clitoris is a **homologous** to the penis in the male:
- **Bartholin Glands :** It is homologous to **Cowper's gland** of male
- A functional rnammary gland is characteristic of all female mammals.
- The milk produced during the initial few days of lactation. is called **colostrum** which contains antibodies **(lgA)** absolutely essential to develop resistance for the new-born babies.

BEGINNER'S BOX - 2

FEMALE REPRODUCTIVE SYSTEM

1. Vagina of the female reproductive system is
(1) Primary sex organs (2) Essential sex organs
(3) Secondary sex organs (4) Both (1) & (2)

2. Development of foetus takes place in
(1) Vagina (2) Uterus (3) Ovary (4) Oviduct

3. Bartholin's glands occurs in
(1) Females' and help in vestibular lubrication
(2) Females and produce oestrogen for regulating secondary sexual characters
(3) Males and form liquid part of spermatic fluid
(4) Males and produce alkaline fluid for neutralising urethral acidity.

4. Abdominal Ostium is the aperture present in
(1) Oviduct (2) Fimbriated fallopian funnel
(3) Ovisac (4) Cloaca

GAMETOGENESIS

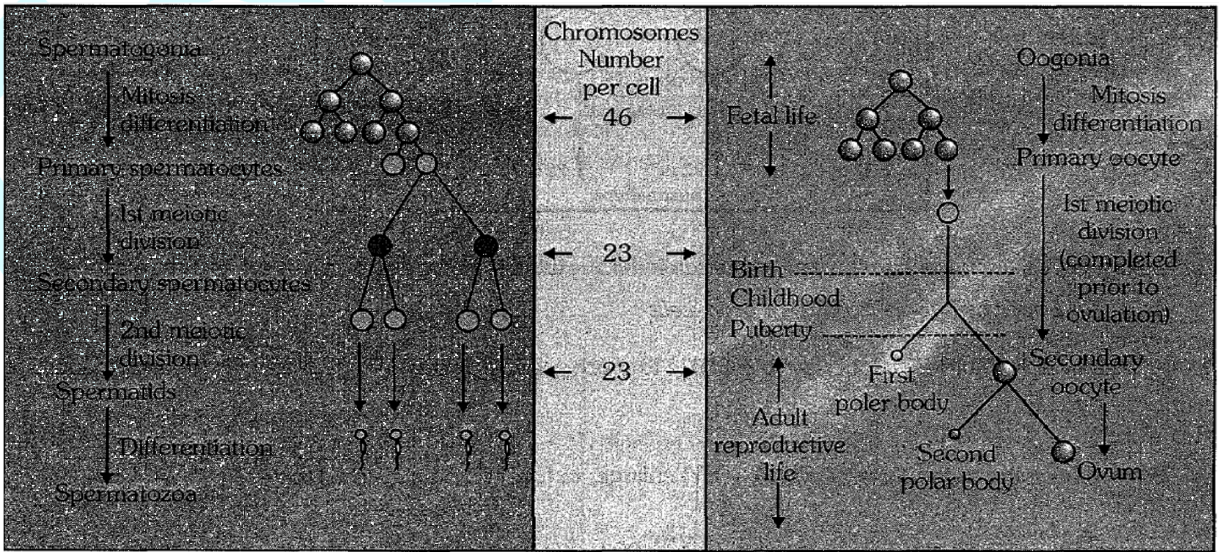
FORMATION OF GAMETES :-

GnRH, FSH, LH regulates gametogenesis. Besides this hormone vitamin E is also essential for gametogenesis. Deficiency of vitamin E leads to sterility. Vitamin A is also required for the formation of healthy gametes.

Gametogenesis is divided in three stages :

(1) Multiplication phase (ii) Growth phase (iii) Maturation phase.

As there are two types of gametes, the spermatozoa and ova, gametogenesis can be studied under two broad headings : spermatogenesis .and oogenesis. **Spermatogenesis** is the formation of spermatozoa, whereas **oogenesis** is the formation of ova. Both spermatozoa: and ova originate from **primordial germ cells** or **PGCs,** which are extra-gonadal in origin. You can recall that spermatogenesis occurs in the seminiferous tubules of the testes and oogenesis occurs in the follicles of ovary. Formation of gametes starts at puberty.



SPERMATOGENESIS

Spermatogenesis : The proecess of formation of spermatozoa in the seminiferous tubules of testis. The wall of seminiferous tubules is lined by cuboidal spermatogonia (male germ cells) and columnar sertoli cells.

Spermatogonia are derived from primordial germ cells.

At puberty spermatogonia divide to form spermatozoa and sertoli cells provide nourishment to developing sperms,-

Sertoli cells form 'blood testes barrier' and protect the sperm from immune system of the body.

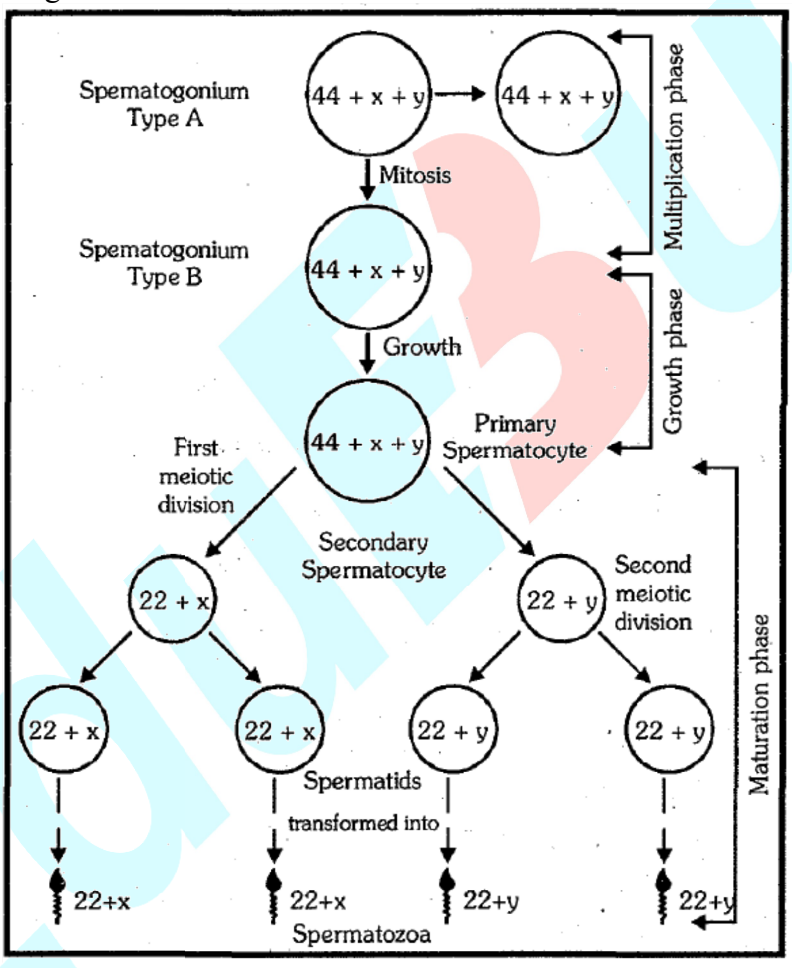
Sertoli cells function as an endocrine gland.

i.e. secrete three types of biochemicals.

(i) **AntimuUerian hormone :** it inhibits mullerian duct in male.

(ii) **lnhibin hormone :** It gives negative feedback to pituitary gland (mainly) and hypothalamus.

(iii) **Androgen binding protein** : It concentrates testesterone in seminiferous tubules to aid spermatogenesis.



Spermatozoa are formed .in the wall of the seminiferous tubules of the testes.

A. The spermatogonia (type A) or germ cells (44 + XY) divide mitotically, to give rise to more spermatogonia of type A and also spermatogonia of type B.

B. The spermatogonia (type B) (44 + XY) enlarge, to form primary spermatocytes.

C. The primazy spermatocytes (44 + XY) now divide so that each of them forms two secondary spermatocytes. This is the first meiotic division : it reduces the number of chromosomes to half.

D. Each secondary spermatocyte has (22 + X or 22+ Y) chromosomes. It divided to from two spermatids. This is the second meiotic division and this time there is no reduction in chromosome number (spermatocytogenesis).

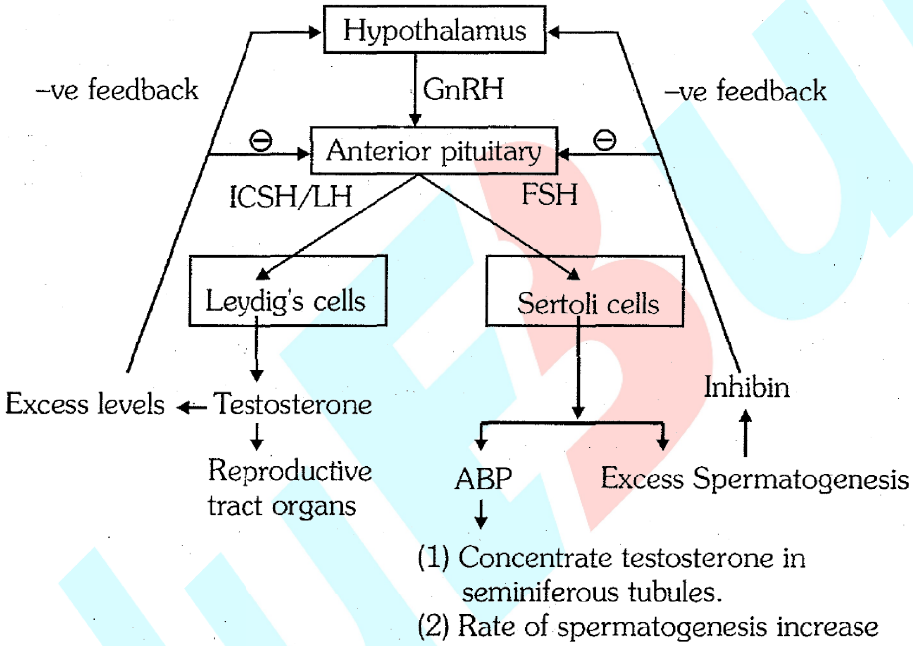
E. Each spermatid (22 + X or 22+ Y) gradually changes its shape to become a spermatozoon. This process of transformation of a circular spermatid to a spermatozoon is called **spermiogenesis/spermateleosis.**

F. In human beings maturation phase is the longest phase of **spermatogenesis**.

Male Reproductive Hormones

FSH : Binds with FSH receptors attached to the Sertoli cells in seminiferous tubules. This causes these cells to grow and secrete various spermatogenic substances and androgen binding proteins (ABP)

LH I ICSH : It stimulates the Leydig cells to secrete testosterone.



Inhibin : It is secreted by Sertoli cells in response to excess spermatogenesis. The inhibin gives a negative feedback to the anterior pituitary (Mainly) and hypothalamus (Neligiable), this results in suppression of synthesis and release of FSH ($\therefore$ Spermatogenesis decreases).

Testosterone : Secreted by Leydig cells. It is essential for

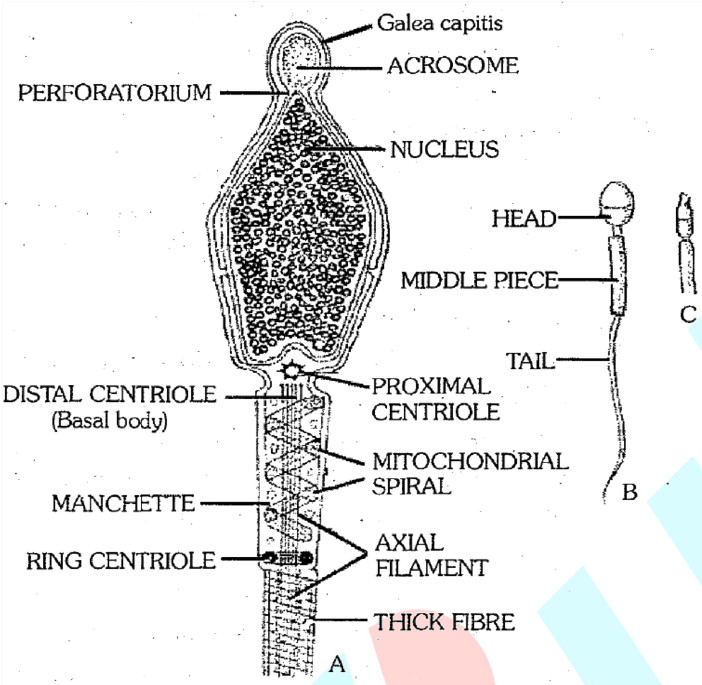
(l) Sperm production

(2) Development of secondary sexual characters

(3) It also gives –ve feedback to hypothalamus and anterior pituitary in its excess concentration to supress GnRH, LHrelease.

(4) It is secreted in foetal stage in as low as 30 ng/ml plasma concentration to cause descent of testis in last trimester of intrauterine life.

Structure of sperm:



Structure of sperm

The spermatozoon has three parts :

(i) Head
(ii) Middle piece
(iii) Tail.

(i) The **head** is covered by a cap called the acrosomic cap, anterior nuclear cap, or galea capitis. Acrosome is a cap like structure filled with lytic enzymes called sperm lysins that help fertilizaiton of the ovum. In the anterior part of middle pices neck is present.

The **neck** is narrow: it contains a proximal & distal centriole (or Basal body). An axial filament begins just behind this centriole, it passes through the middle piece and extends into the tail. At the point where the middle piece joins the tail, this axial filament passes through a ring-like structure called the annulus (or ring centriole or zensons ring). That part of the axial filament which lies in the middle piece, is surrounded by a spiral sheath made up of mitochondria. (Nebenkern sheath), which produce energy for the movement of tail than facilitate i sperm motility essential for fertilization. Nuclear part of head of spermatozoa consist of chromatin (mostly DNA) that is extremely condensed. It contains a basic nature protein called protamine.

The axial filament, that passes through the middle piece and most of the tail, is actually composed of several fibrils arranged. There is a pair of central fibrils; surrounded by nine pairs (doublets) arranged in a circle around the central pair.

(ii) **Middle piece** (also called as the energy chamber) is surrounded by spirally arranged mitochondria (Nebenkern sheath). Finally; the entire sperm is enclosed in a plasma membrane.

- Thin layer of cytoplasm is found in middle piece which is known as manchette.
- Ring centriole (function unknown) is present at distal end of middle piece.

(iii) **Tail :** The longest part of sperms.

Sperm moves by help of tail.

- Distal centriole acts as basal body and produce axonema.

OOGENESIS

The process of formation of a mature female gamete is called Oogenesis.

Like spermatogenesis oogenesis process also can be divided into th~ee stages :

(A) Multiplication phase (B) Growth phase (C) Maturation phase

(A) Multiplication phase :

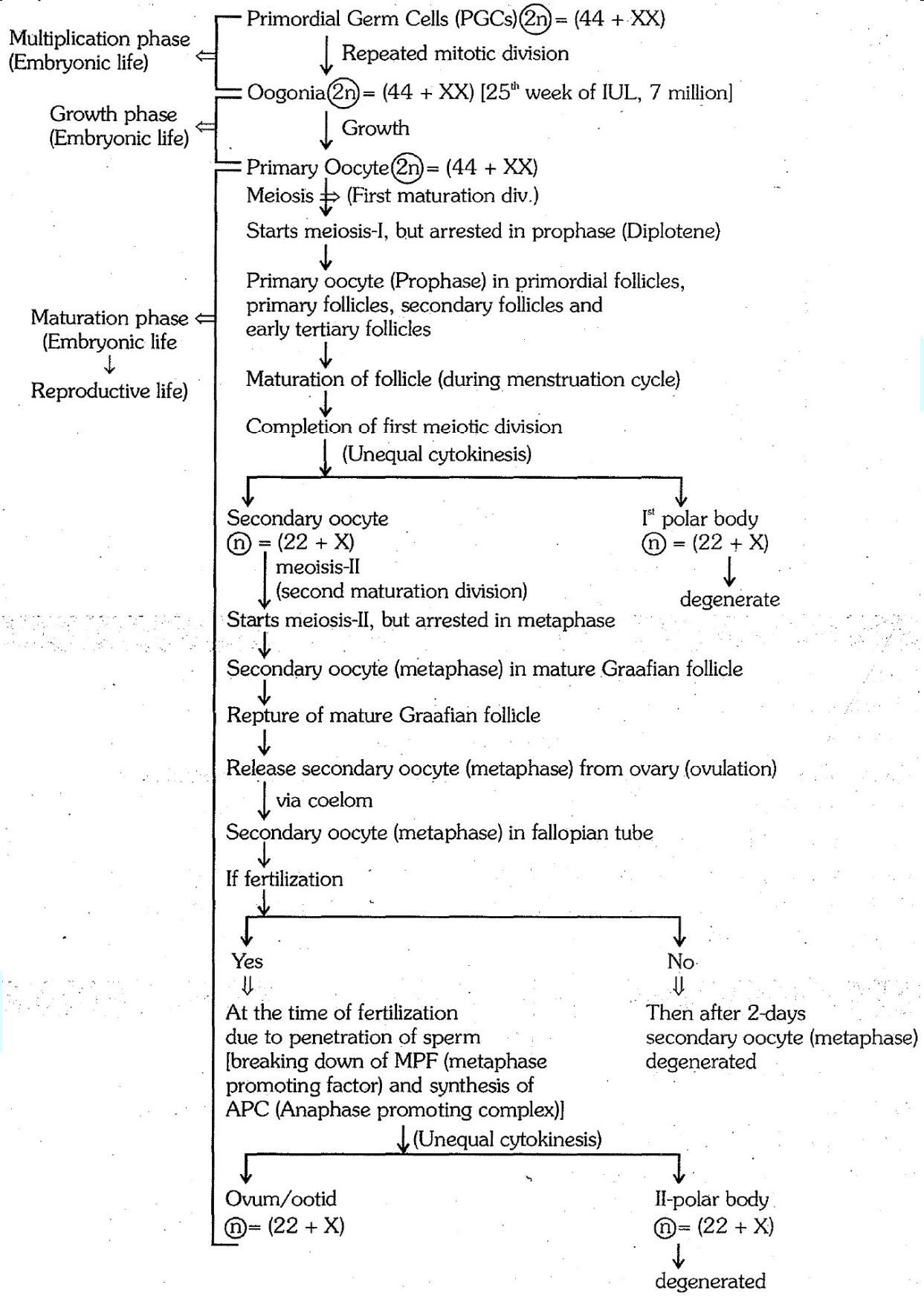
- During embryonic development stage primordial germ cells or gamete mother cells repeatedly divide by mitosis to form large number of diploid oogonia in each fetal ovary, no mre oogonia are formed and added after birth.
- This process completes in embryo stage of female in most higher animals.

(B) Growth phase :

- Like spermatogenesis, in this process oogonia grow in size and form primary oocytes.
- The growth phase is the longest phase in oogenesis in oviparous animals.
- During growth phase size of egg increases many times.

(C) Maturation phase:

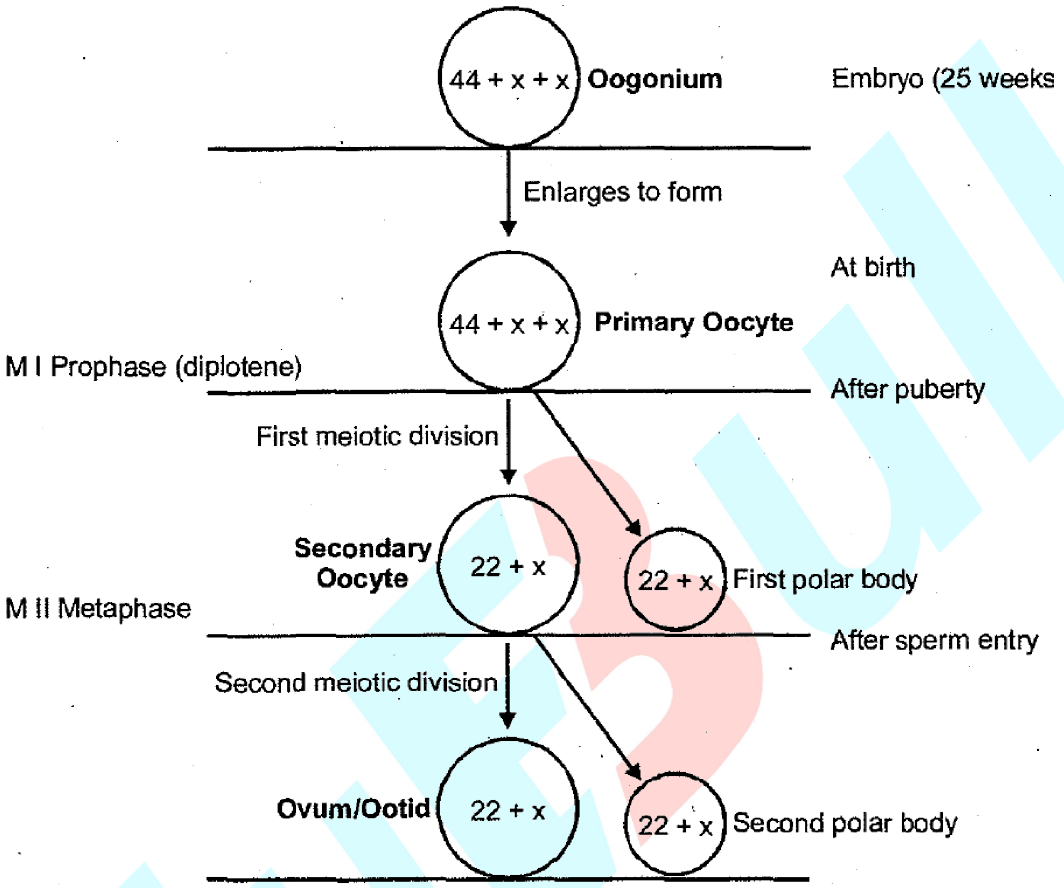
- It is the longest phase in human.
- In contrast to males the initial steps in egg production occur prior to birth. By the time the foetus is 25 weeks old, all the oogonia that she will ever produce, are already formed by mitosis. These diploid cells develop into **primary oocytes,** begin the first steps of the first meiotic division, proceed up to diplotene (prophase-I) and then stop any further development. The oocytes grows much larger and completes the meiosis I, forming a large **secondary oocyte** and a small **polar body** that receives very little amount of cytoplasm but one full set of chromosomes.
- First polar body may undergo degeneration do to lack of cytoplasm or may divide.
- Whereas the secondary oocyte proceeds as far as the **metaphase** stage of meiosis II. However, it then stops advancing any further, it awaits the arrival of the spermatozoa for completion of second meiotic division.
- Entry of the sperm restarts the cell cycle breaking down **MPF** (Metaphase promoting factor and turning on the **APC** (Anaphase promoting complex). Completion of meiosis **II** converts the secondary oocyte into a fertilised egg or zygote (and also a second polar body)



Some important differences between oogenesis and spermatogenesis are

(1) Whereas one primary spermatocyte gives rise to four spermatozoa, one primary oocyte forms only one ovum.

(2) When the primary spermatocyte divides, its cytoplasm is equally distributed between the two secondary spermatocytes formed. However, when the primary oocyte divides, almost all its cytoplasm goes to the daughter cell which forms the secondary oocyte. The other daughter cell (first polar body), receives half the chromosomes of the primary oocyte, but almost no cytoplasm.



GOLDEN KEY POINTS

- Liberation of sperms from Sertoli cells of seminiferous tubules is called **spermiation**.
- Liberation of sperms from testes is called **semination**.
- Liberation of sperms from body bf male is called **ejaculation** .
- Mammalian sperms are transfered to vagina of female by the process called **insemination**.
- In 1 ml of semen, 20 to 120 millions of sperms are present in human being.
- Leydig's cells mature at 10 yrs. of age.
- In humans (and most vertebrates), the first polar body does not undergo meiosis II.
- The first polar body is, therefore, formed merely to get rid of unwanted chromosomes.
- 65-74 days are required to complete the cycle of spermatogenesis in human being.

BEGINNER'S BOX-3
GAMETOGENESIS

1. The human sperm was first discovered by :-
(1) Von Baer (2) Leeuwenhoek (3) Robert hook (4) Darwin

2. "Spermiogenesis" is a process in which :
(1) spermatids change into spermatozoa
(2) spermatogonia produce a spermatid
(3) spermatocytes give rise to spermatozoa
(4) dormant spermatozoa become active just before ejaculation.

3. Spermatogenesis and sperm differentiation are under the control of
(1) FSH (2) LH (3) Progesterone (4) Parathyroid Harmone

4. Spermatogenesis process occur in
(1) Rete testis (2) Seminiferous Tubules
(3) Septula testis (4) Mediastinum testis

5. Acrosome formation in spermatogenesis occurs in which stage?
(1) First meiotic division (2) Second meiotic division
(3) Growth phage (4) Spermiogenesis

6. 10 oogonia yield 10 primary oocytes, thenhow many ova are produced on completion of oogenesis
(1) 5 (2) 10 (3) 20 (4) 40

7. The minute cells which separate from the developing ova during their maturation are called
(1) Primary Oogonia (2) Secondary Oogonia
(3) Polar bodies (4) Primary spermatogonia

8. Sperm differs from egg in having :-
(1) Power of motility (2) No stored food
(3) More in numbers (4) All of the above

9. How many polar bodies are produced during the entire process of oogenesis in unmarried human female ?
(1) Three (2)Two (3) One (4) Four

STRUCTURE OF OVARY

Outer most layer of ovary is called germinal epithelium while the inner layer called T. albuginea is made up of

White fibrous connective tissue.

The inner part of ovary is called as stroma. it is differentiated into 2 parts. outer peripheral part is cortex & inner part is called medulla. Stroma consists of follicular cells, connective tissues, blood vessels & lymphatics.

Numerous oog_onial are found in cortical region in intrauterine life.

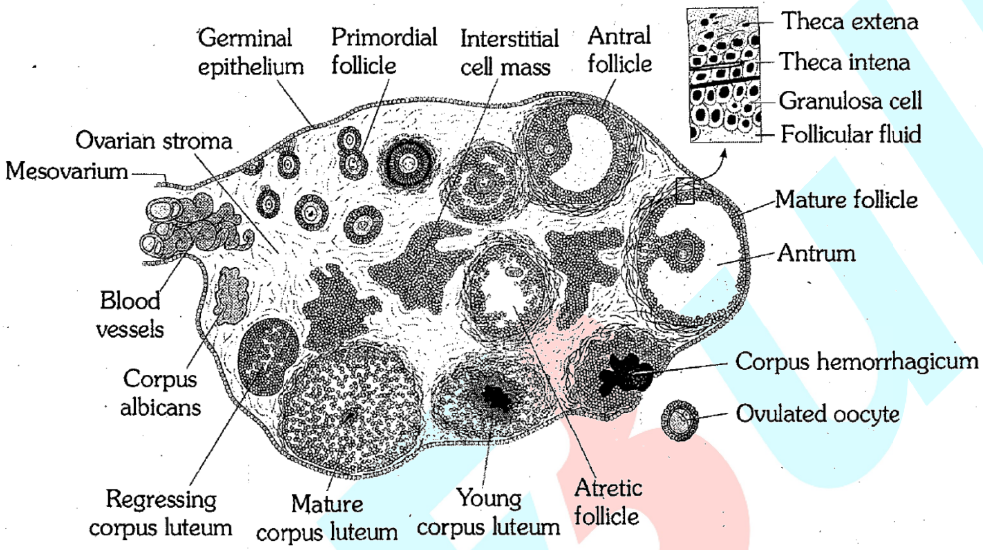


Diagram of a mammalian ovary

FORMATION OF OVARIAN OR GRAAFIAN FOLLICLE

Ova develop from oogonia present in the cortex of the ovary. The oogonia are surrounded by other cells that form a stroma for them. These stromal cells form the ovarian or Graafian follicle that surrounds the ovum and protects it.

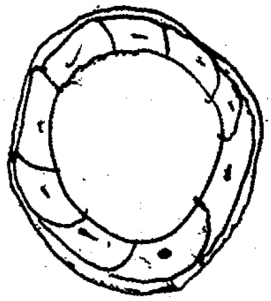
The stages is formation of **Graafian** follicle are as follows :

(1) PRIMORDIAL FOLLICLE (Developing primary follicle)

Firstly some cells of the stroma become flattened and surround a primary oocyte (which develops from oogonia).

These flattened cells ultimately form the ovarian follicle and are therefore called follicular cells.

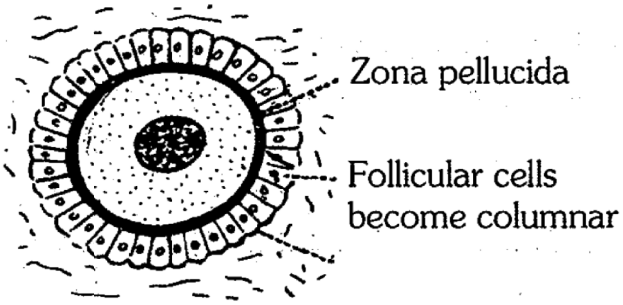
The flattened follicular cells now become columnar. Follicles upto this stage of development are called primordial follicle.



Primordial follicle

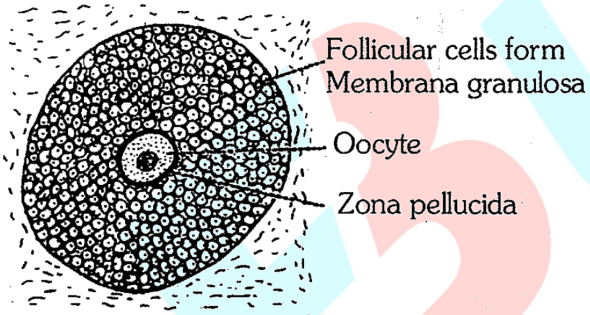
(2) PRIMARY FOLLICLE

A glycoprotein membrane called the zona pellucida,. now appears between the follicular cells and the oocyte.



Early Primary follicle

The follicular cells proliferate now to form several layers of cells to form the membrane granulosa. These cells are now called granulosa cells. this stage of follicle primary follicle. Therefore. at puberty only 60.000-80.000 primary follicles are left in each ovary.



Late Primary follicle

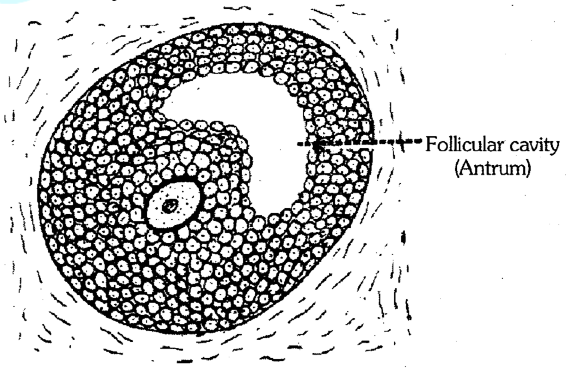
(3) SECONDARY FOLLICLE ;·

As the follicle expands, the stromal cells surrounding the membrana granulosa become condensed to form a covering called the theca Interna. The cells of theca interna (Thecal cells) afterwards secrete a hormone called oestrogen.

Outside the theca interna some fibrous tissue become condensed to form another covering called the theca extern.

(4) TERTIARY FOLLICLE

A cavity appears within the membrana granulosa. It is called the **antrum** having liquor follicle). With the appearance of this cavity, the follicle is formed (follicle means a small sac). Theca layer is organised clearly into an inner theca interna and outer theca externa.

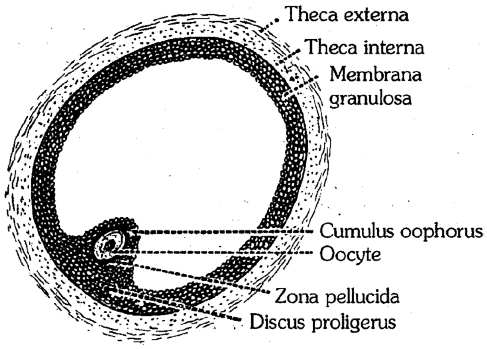


Tertiary follicle

(5) MATURE TERTIARY FOWCLE/GRAAFIAN FOWCLE

The cavity of the follicle rapidly increases in size and gets filled with a fluid called liquor folliculi. Due to increase in the size of the cavity the wall of the follicle (formed by granulosa cells) becomes relatively thin. The oocyte now lies eccentrically in the follicle, surrounded by some granulosa cells that are called as cumulus oophoricus or oophorus.

The cells that attached it to the wall of the follicle are called as discus proligerus or Germ hill.



Graafian follicle

The ovarian follicle is now fully formed and is now called the Mature Graafian Follicle (M.G.F.)

The granulosa cells lying in the close vicinity of the zona pellucida, become elongated to form the corona radiata.

After 13 days of menstrual cycle (on 14th day when cycle is ideally for 28 days) Graafian follicle is ruptured & released, Secondary oocyte (meta phase) or egg.

FORMATION OF CORPUS LUTEUM

Before ovulation the inner side of follicle is avascular but soon after ovulation blood vessels grow into ruptured graffian follicle becomes filled with blood which is known as corpus heamorrhagium. It is a initial stage of corpus luteum.

The granulosa cells of ruptured graafian follicle proliferete and these cells become yellow due to accumulation of pigment called lutein. These cells are called lutein/luteal cells. Lutein cells secrete progesterone. Estrogen is also secreted by corpus luteum.

FATE OF CORPUS LUTEUM

Fate of Corpus Luteum

Fertilization

Implantation

Yes

Corpus luteum become stable for next nine months by the help of hCG secreted by itself embryonic cell trophoblast or blastocyst

No

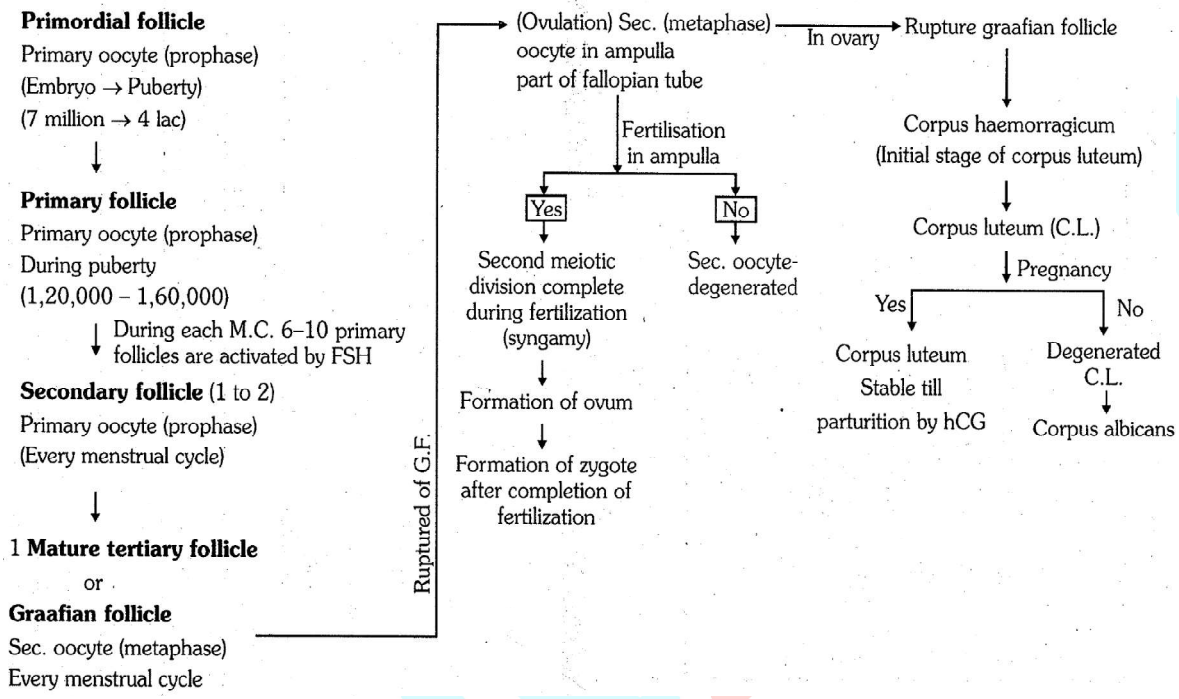
Corpus luteum start degenerating after about 9 days of its formation and converted into corpus albicans i.e. about 23rd day of m.c. Degenerated C.L. is known as corpus albicans

Progesterone hormone maintains pregnancy and repairs the wall of uterus to make its surface adhesive to help in implantation.

Due to action of estrogens and progesterone, the endometrium of uterus is prepared for implantation. By the 6th to 7th day of fertilization, embryo is implanted into endometrium (most commonly at the **fundus**).

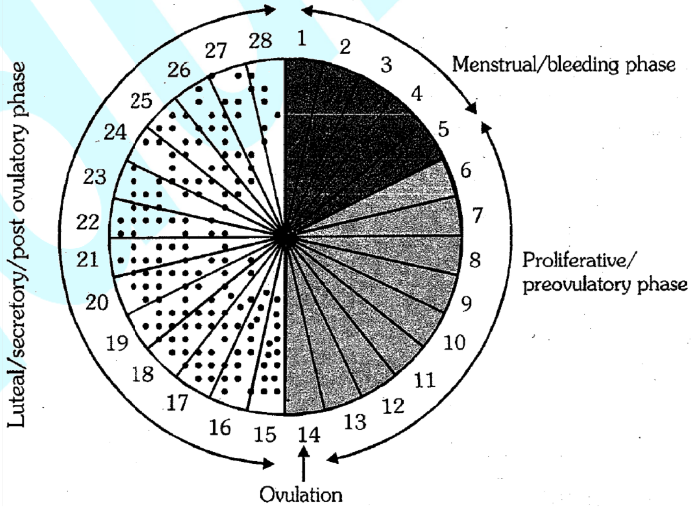
The total number of follicles in the two ovaries of a normal young woman is about four lakhs. However most of them undergo regression and disappear due to death and are disposed off by the phagocytes during the reproductive years of the females. This is termed as **follicular atresia**. This is responsible for limited number of gamete production in females. Generally, only one owm is liberatedin each menstrual cycle, by alternate ovaries.

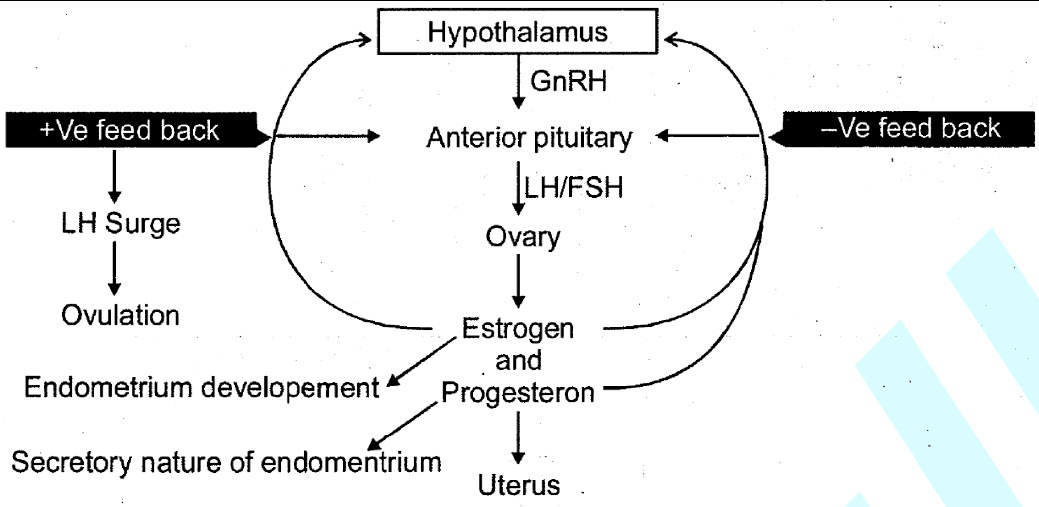
During copulation oxytocin hormone is secreted from pituitary gland. This hormone promotes the peristalsis in the fallopian tube & uterus. Due to this the semen is sucked into fallopian tube.



MENSTRUAL CYCLE

Duration- 28 days Ideally (Range - 22 to 32 days)





	Estrogen		Progesterone (Antiabortion or pregnancy hormone)
1.	Endometrial hyperplasta.	1.	Increase secretory nature of endometrium (Developement of glands)
2.	Increase vascularity of endometrium (Uterine arteriole become tortuous)	2.	Increase adhesive nature of endometrium.
3.	Myometrial hypertrophy	3.	Decrease myometrial contraction.
4.	Ultimately increase thickness of uterine wall.	4.	Maintain thickness of uterine wall.

This is exhibited by primate group of animals. In this cycle the female body prepares itself for a possible pregnancy. If the pregnancy does not occur then the body aborts all preparation done and restarts the prepration for pregnancy again in a monthly cyclic manner.

Menstrual cycle has three main phases :

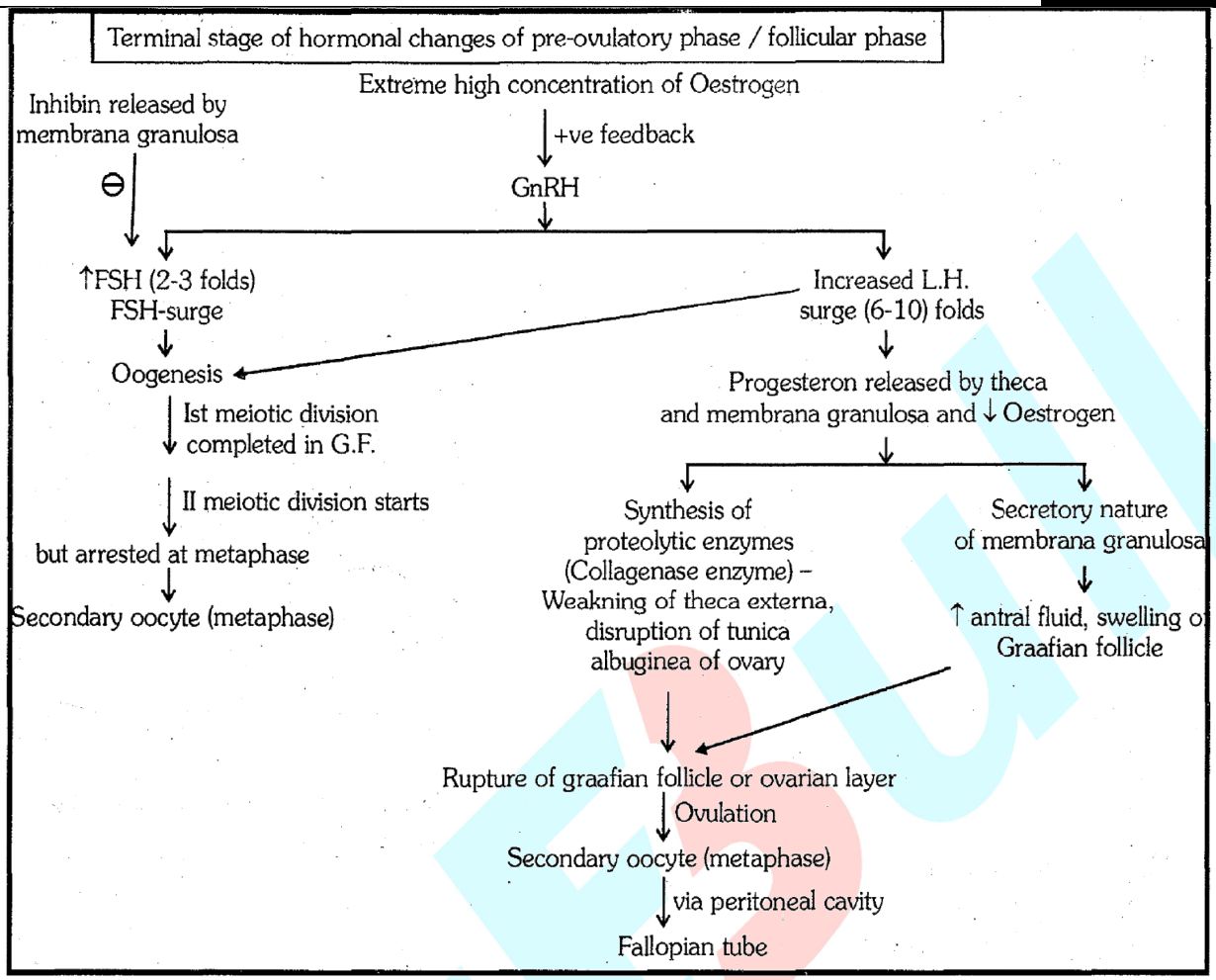
(i) Bleeding phase or menstruation phase.

(ii) Proliferative/preovulatory/follicular phase or oestrogenic phase.

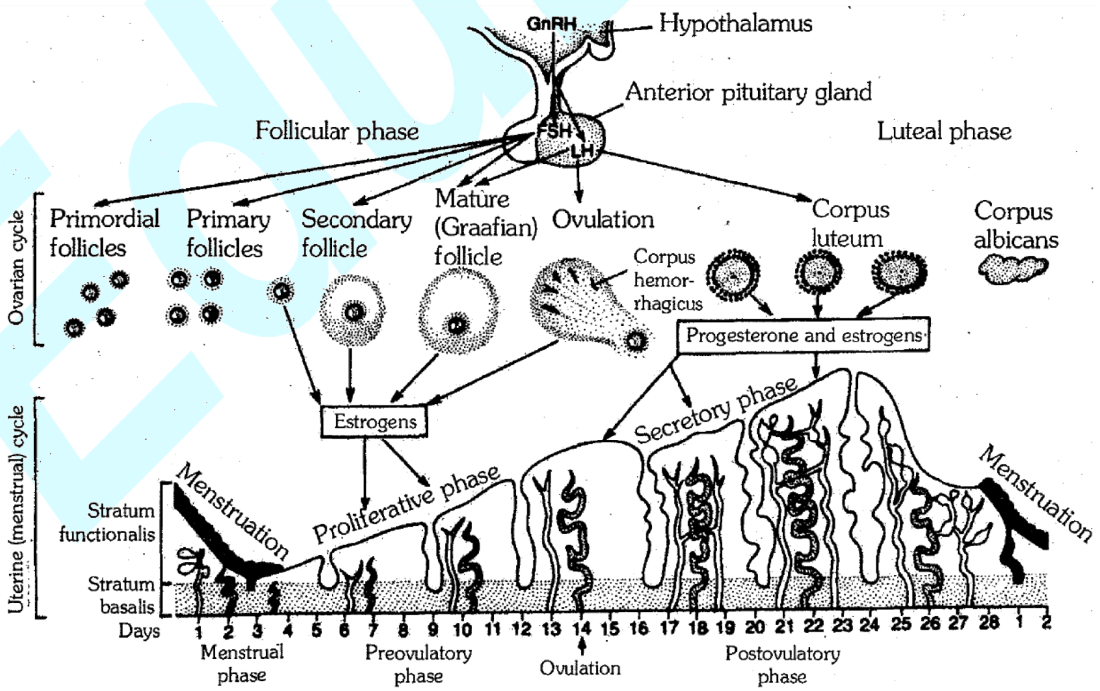
(iii) Secrectory/post ovulatory/luteal phase or progesteronic phase.

	Phase	Hormonal changes	Ovarian changes	Uterine changes
1. BLEEDING PHASE (4-5 days)				
(a)	Initial stage	GnRH, FSH, LH Estrogen and progesterone are low	Complete degeneration of corpus luteum (Corpus albicans)	Due to withdraw of sex hormone, progesterone are formed in uterus which cause arteriolar vasoconstriction. It leads to decreased blood supply to **stratum functionalis** that result in its degeneration and separation. Prostaglandin also cause contraction of myometrium which leads to sloughing of dead endometrial tissue (stratum functionalis) with blood from uterine cavity through vagina. This bleeding continues upto 4-5 days and clotting does not occur due to presence of fibrinolytic enzymes.

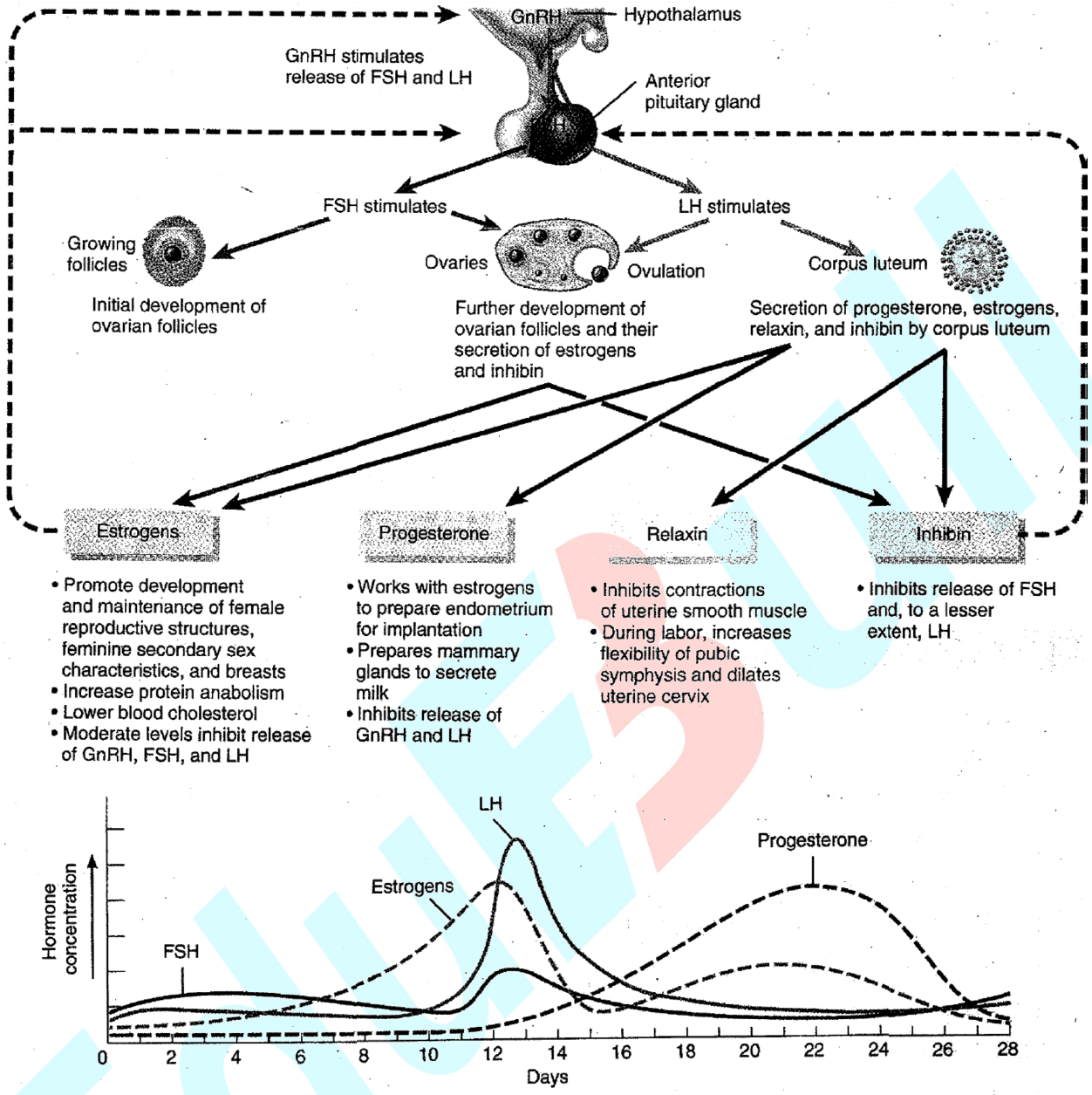
				Average 40 to 80 ml blood loss per cycle.
(b)	Terminal stage	GnRH↑, FSH↑, LH↑, due to negative feedback of low level of estrogen and progesterone.	6-12 primary follicles are stimulated and start formation of secondary follicle.	Uterine bleeding is gradually reduced.
2. FOLLICULAR/PROLIFERATIVE/ESTROGENIC/PREOVULATORY PHASE.				
(a)	Initial stage	GnRH↑, FSH↑, LH↑, Estrogen↑	1-2 Secondary follicle → 1 Tertiary follicle	• Uterine bleeding is stopped. • Endometrial hyperplasia. • Formation of stratum functionalis
(b)	Terminal stage	PTO (refer next page)	Tertiary follicle → 1 mature tertiary follicle (Graafian follicle)	• Thickness of uterine wall increased • Myometrium hypertrophy.
3. LUTEAL/SECRETORY/PROGESTERONIC/POST-OVULATORY PHASE. (Fix of 14 days)				
(a)	Initial stage	GnRH, LH, FSH are comparatively low than terminal stage of follicular phase	Ruptured graafian follicle ↓ Cropus hemorrhagicum ↓ Corpus luteum (maximum developed on 22nd day)	• More secretory (glandular) nature of endometrium. • Thickness of uterine wall maximum (23rd day)
(b)	Terminal stage	Increased progesterone give negative feedback ↓ GnRH, LH significantly low Further decrease of progesterone and estrogen due to degeneration of corpus luteum	Corpus luteum degeneration (Corpus albicans on 28th day does not secrete any homone)	• Size of stratum funcitonalis decrease. • Thickness of uterine wall decrease. • Myometrial atrophy.



On basis of the above data, safe period method for family planning is calculated. Normally it is considered to be day 1 to day 8 and then from day 20 to day 28.



Schematic representation of menstrual cycle



(b) Changes in concentration of anterior pituitary and ovarian hormones

Menstrual Hygiene : Menstrual Hygiene Maintenance of hygiene and sanitation during menstruation is very important. Take bath and clean yourself regularly. Use sanitary rapkins or clean homemade pads. Change sanitary napkins or homemade pads after eveny 4-5 hrs as per the requirement. Dispose of the used sanitary napkins pro pertly wrapping it with a used paper. Do not throw the used napkins in the drainpipe of toilets or in the open area. After handling the napkin wash hands with soap.

- Lack of menstruation may be indicative of pregnancy. However. it may also be caused due to some other underling causes like stress. poor health etc.
- Only about 450 ova are produced by a human female over the entire span of her reproductive life which lasts till about 50 years of age.
- In rabbit ovulation occurs after 12-24 hour of copulation. That means copulation is necessary for ovulation. Females in which coitus induction is compulsary for ovulation are called as **induced or reflex ovulator**.
- In human female ovulation occurs in presence of FSH & LH. Coitus is not necessary for inducing ovulation. Such a female is called as **spontaneous ovulator**.
- In human beings, menstrual cycles ceases around 50 years of age; that is termed as **menopause**. Cyclic menstruation is an indicator of normal reproductive phase and extends between menarche and menopause.
- Although most of the follicular cells and the oocytes undergo degeneration during follicular atresia, some thecal cells, formed from the stroma and located around the follicle, persist and become active. These are called interstitial cells. These cells secrete small amount of androgen. No specific breeding season is found in human being.
- In entherian mammals (other then primates) reproductive cycle is estrus cycle which occurs during specific breeding season.
- **Amenorrhoea** - Absence of menstruation cycle.
- **Precocious puberty :** Menstruation occurs before the age of 8 years.
- Pregnancy is detected with the help of HCG in urine of pregnant lady.
- **Cryptomenorrhea :** Occurrence of menstrual symtoms without external bleeding.
- **Dysmenorrhoea :** Painful menstruation is called Dysmenorrhoea.
- **Menorrhagia:** A normal menstrual blood loss is 50-80 ml, and does not exceed 100 ml. In menorrhagia the menstrual cycle is unaltered but the duration and quantity of the menstrual blood loss are increased.
- **Polymenorrhoea :** In polymenorrhoea or epimenorrhoea, the menstrual cycle is reduced from the normal of twenty-eight days to a cycle of two to three weeks and remains constant at that increased frequency.

BEGINNER•s BOX-4

OVARIAN FOWCLES AND MENSTRUAL CYCLE

1. Estrogen is mainly secreted by
(1) Corpus luteum (2) Theca interna of Graafian follicle
(3) Germinal epithelium of ovary (4) Pituitary

2. Atretic follicle is
(1) Which are not developed completely and degenerate
(2) Other name of corpus luteum
(3) Which extruded its oocytes
(4) Graafian follicle

3. Number of eggs released in the life time of a woman is approximately
(1) 40 (2) 400 (3) 4000 (4) 20000

4. Corpus luteum develops from
(1) Oocyte (2) Nephrostome (3) Graafian follicle (4) Antrum

5. Process by which Graffian follicles are formed in the ovary is known as
(1) Oogenesis (2) Luteinisation (3) Folliculogenesis (4) All

6. First menstrual cycle starts at
(1) Parturition (2) Menopause (3) Puberty (4) Implantation

7. Menstrual cycle is generally of
(1) 21 days (2) 28 days (3) 38 days (4) 40 days

8. Mainly which type of hormones control the menstrual cycle in human beings :
(1) FSH (2) LH (3) FSH, LH, Estrogen (4) Progesterone only

TYPES OF EGGS

(A) On the basis of amount of yolk

Alecithal
- Negligible amount of yolk
- [Cytoplasm >>> yolk]

eg. : Human

Microlecithal or Oligolecithal
⇓
- Very less amount of yolk
- [Cytoplasm >> yolk]

eg. : – Eutherian
– Metatherian
– Amphioxus
– Sea-urchin
– Protochordata

Mesolecithal
⇓
- Almost equal amount of yolk
- [Cytoplasm ≈ yolk]

eg. : – Amphibia
– Petromyzon
– Lung-fishes

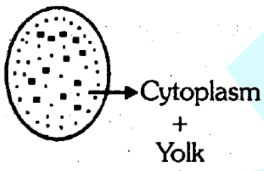
Polylecithal or Macrolecithal or Megalecithal
⇓
- Large amount of yolk
- [Cytoplasm << yolk]

eg. : – Prototherians
– Birds
– Reptiles
– Insects

(B) On the basis of yolk

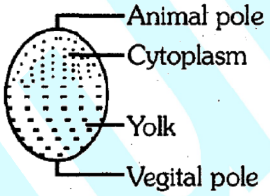
Isolecithal or Homolecithal
⇓
Yolk is homogenously distributed in egg

eg. : – Alecithal egg
– Microlecithal egg



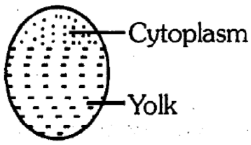
Telolecithal

Moderate telolecithal
⇓
Yolk is concentrated in one part of the egg.



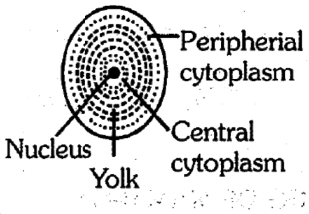
eg : Amphibian eggs (mesolecithal eggs)

Highly telolecithal or Discoidal egg
⇓
Yolk is in enormous quantity and concentrate in one part of the egg. Cytoplasm in small quantity and present in the form of germinal disc

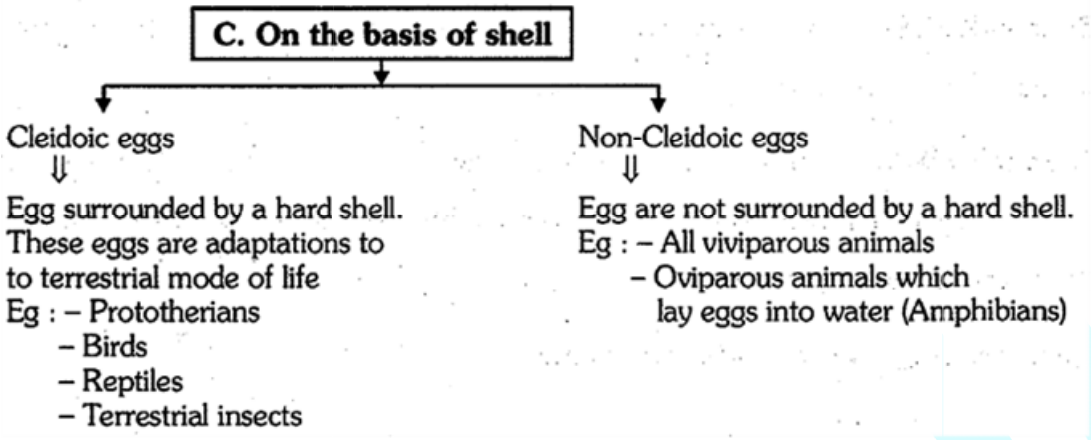


eg. : – Prototherians
– Birds
– Reptiles

Centrolecithal
⇓
Placement of the Yolk in the center of the cytoplasm of ovum and cytoplasm is in the form of superficial layer around the yolk



eg. : Insects



STRUCTURE OF AN OOCYTE

The nucleus of egg is also called germinal vesicle.
Oocyte is surrounded by membranes termed as the egg-membranes.
Oocyte / Ovum along with the egg-membrane are termed as the egg.
Egg = Ovum / Oocyte + Egg membrane.
Majority eggs are oval but the eggs of insects are long and cylindrical. Smallest eggs are of 50µ in polychaeta and the largest eggs are of an Ostrich.

Classification of egg - membranes :-

On the basis of origin, egg- membranes are of 3 types:-.

(1) **Primary egg membrane:** This membrane is secreted by the oocyte itself.
eg. Vitelline membrane, Zona Pellucida (mammals).

(2) **Secondary egg membrane :** This is found outside the primary egg membrane and is secreted by the ovary. (eg. Corona radiata, Chorion)

(3) **Tertiary egg membrane :** This is present outside the primary egg membrane. It is either secreted by the uterus or the oviduct. (eg. Jelly coat, Shell & Shell membrane)

Functions of Egg-membranes

(i) To provide protection
(ii) To check polyspermy
(iii) To provide buoyancy to the amphibian eggs
(iv) To prevents the egg from dessiciation

EGG OF MAMMALS:-

Mammalian eggs have very less amount of yolk, so the eggs are oligolecithal and isolecithal or microlecithal and homolecithal .
The egg has 2 egg-membranes:-
(1) Zona pellucida :- This is a transparent membrane like covering and is a primary membrane secreted by the ovum/oocyte itself.
(2) Corona radiata :- This is a layer of follicular cells" and these cells are attached to the surface of egg through "hyaluronic acid" This is a secondary membrane, which is secreted by the ovary. These eggs don't have tertiary membrane.
Mammalian eggs are approx 0.1 mm in size.

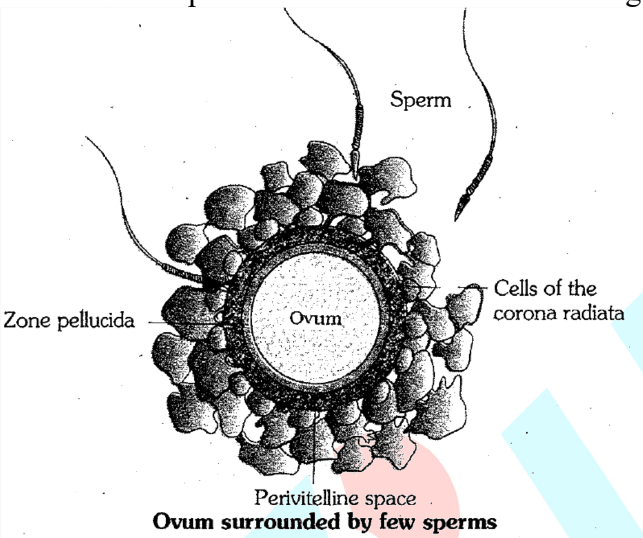
FERTILIZATION

The process in which union of male and female gametes (formed by gametogenesis) and fusion of pronuclei of sperm and ovum takes place thus diploid zygote is formed, is called fertilization.

Fertilization has following processes:- The union of male and female gametes is called **Syngamy**, where as intermixing of their cytoplasm is called **plasmogamy**. The fusion of pronuclei of sperm and ovum is called **karyogamy**. The intermingling of their chromosomes is called **amphimixis**.

Due to fertilization, a diploid zygote is formed, by the union of two different types of gametes.

MECHANISM - We can understand the process of fertilization in following steps.



Ovum surrounded by few sperms

Mechanism of fertilization :

1. Movement of sperms towards the secondary oocyte.

↓

2. Penetration of corona radiata by the hyaluronidase enzyme.

↓

3. Adherence of sperm to the **ZP_3 receptors/region** on zona pellucida, the glycoprotein layer surrounding the oocyte.

↓

4. Sperm bind to a sperm receptor on the zona and this leads to initiation of acrosomal reaction. Various enzymes are released. eg. **Acrosin (Zona lysin)**.

↓

5. **Acrosin** facilitate the penetration of sperm through zona pellucida.

↓

6. Fusion of sperm and membrane of secondary oocyte**. (Syngamy)**

↓

7. Phagocytosis of sperm by the secondary oocyte.

↓

8. Completion of meiosis-II of secondary oocyte during phagocytosis to form ovum and simultaneously it releases 2nd polar body.

↓

9. Structural changes in zona pellucida through **cortical reaction** and discharge of cortical granules in perivitelline space forms **fertilization membrane,** which prevent polyspermy.

↓

10. In the event of fertilization complete sperm enters inside the ovum. (By phagocytosis)

↓

11. It is followed by plasmogamy, karyogamy and amphimixis i.e. completion of fertilization.

Fate of spenn in egg :

In majority of animals, only head and middle piece enter inside the egg and tail is left outside. In mammals, whole sperm enters in the egg.

All the structures of sperm dissolve in egg cytoplasm except sperm nucleus proximal centriole. The centriole of egg itself degenerates at the time of second maturation division. So proximal centriole of sperm starts division, it divides into 2 daughter centrioles, which migrate towards opposite pole and start forming spindles.

Fate of spenn nucleus:-

The nucleus of sperm absorbs water from egg cytoplasm and becomes enlarged. Now it is called **male pronucleus.**

Male pronucleus and female pronucleus migrate through definite routes and come close to each other. These routes are called fertilization path.

Significance of Fertilization

1. Secondary oocyte completes its second maturation division on coming in contact with the sperm.
2. Amphimixis process leads to the formation of a diploid zygote to restore the normal diploid number of the chromosomes.
3. The centriole of sperm after entering into egg induces the egg to undergo cleavag.
4. The paternal and maternal characters are transmitted to the offsprings through the process of fertilization.
5. The peripheral changes occurring in the egg prevent the further entry of sperm into the ovum, thus checking polyspermy.

BEGINNER'S BOX-5

TYPES OF EGGS AND FERTIUZATION

1. In mammals, egg is fertilised in :-
(1) Ovary (2) Fallopian tube (3) Uterus (4) Vagina

2. Fertilization is :
(1) Union of diploid spermatozoon with diploid ovum to form diploid zygote
(2) Union of haploid sperm with haploid ovum to form haploid zygote
(3) Union of haploid sperm with haploid ovum to form diploid zygote
(4) Union of diploid sperm with haploid ovum to form triploid zygote

3. External fertilization occurs in animals, which
(1) Lay eggs on land (2) Lay eggs in water
(3) Oviparous (4) Viviparous

CLEAVAGE (Cellulation or segmentation)

- The term 'Cleavage' was given by **"Von Baer"**.
- In fertilized egg or activated egg, the egg undergoes repeated cell divisions which occur rapidly producing a multicellular structure without changing its size. All these rapid mitotic cell divisions are collectively called cleavage or segmentation. Due to the process of cleavage, a single celled zygote, through a successive mitot1c cell d!visions changes into a complex multicellular structure. Cells produced as a result of cleavage_ are termed as blastomeres.

	Cleavage	Normal Mitosis
(1)	Newly formed cells are known as blastomeres	Newly formed cells are known as daughter cell
(2)	Interphase is short, only 'S' phase is present	Interphase are long G, S, G_2 phase are present
(3)	Karyoplasmic index increses	Karyoplasmic index remain constant.

CLASSIFICATION OF CLEAVAGE

On the basis of fate of blastomere

Determinate cleavage

The fate of blastomere is fixed, determined i.e. blastomere forms a particular portion or embryo
eg. Nematoda, annelida, mollusca

Indeterminate cleavage

The fate of blastomere is not definite. These are totipotent in early stage of embryo
eg. Human

ClASSIFICATION OF ClEAVAGE

On the basis of amount of Yolk :-

A scientist named **Balfour** gave a law. According to him, rate of cleavage is inversely proportional to amount of yolk present in the egg. The yolk present in egg, disturbs the rate of cleavage. The rate of cleavage is slow in that part of egg, in which amount of yolk is more, and the rate of cleavage is faster in the portion of egg in which yolk is in lesser amount. Mostly cleavage is of 2 types :-

Complete or holoblastic

→ When cleavage furrow passes through the egg completely

→ Whole egg divides

Equal holoblastic
– Blastomere are of same size
Eg. Homolecithal/esolecithal
egg. Mammals
(eutherian, metatherian)

Uriequal holoblastic
– Blastomere unequal size.
eg. Mesolecithal, Human

Meroblastic / Incomplete

→ Cleavage does not occur in the part of egg, where Yolk is present

→ Cleavage occurs only in cytoplasmic part

→ Found in Megalecithal eggs.

Discoidal meroblastic cleavage
eg. Birds, Reptile, prototherian mammals

Superficial Meroblastic cleavage
eg. Centrolecithal egg of insects

Significance of Cleavage -

1. There is no change in shape and size of developing embryo till end stage of gastrula stage comes. Till then it remains just like undivided egg in shape.
2. As a result of cleavage, unicellular zygote changes into multicellular structure.

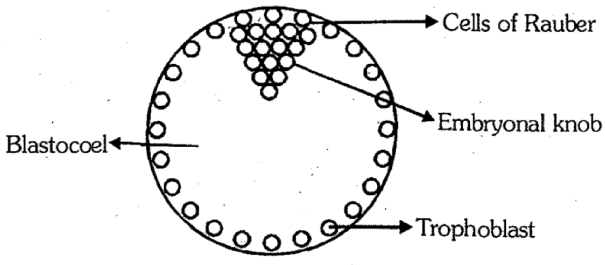
GENERAL STAGES OF EMBRYONIC DEVELOPMENT

1. **Morula-** As a result of segmentation or cleavage activities, unicellular zygote changes into a solid ball like multicellular structure. In the later stage of cleavage, dusters of sticky, cohering, protruding (outside) blastomeres are produced, which look like mulberry. This stage is termed as morula stage.

The mitotic division starts as the zygote moves through the isthmus of the oviduct called cleavage towards the uterus and forms 2, 4, 8, 16 daughter cells called blastomeres. The embryo with 8 to 16 blastomeres is called a morula.

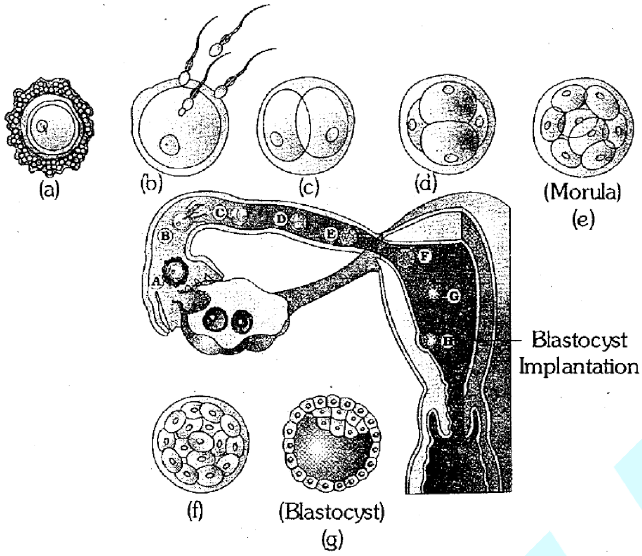
2. **Blastulation :-** The morula continues to divided and transforms into blastocyst. **Blastocyst**-Blastula of eutherian and metatherian mammals- is called blastocyst, because blastula is in the form of a cyst.

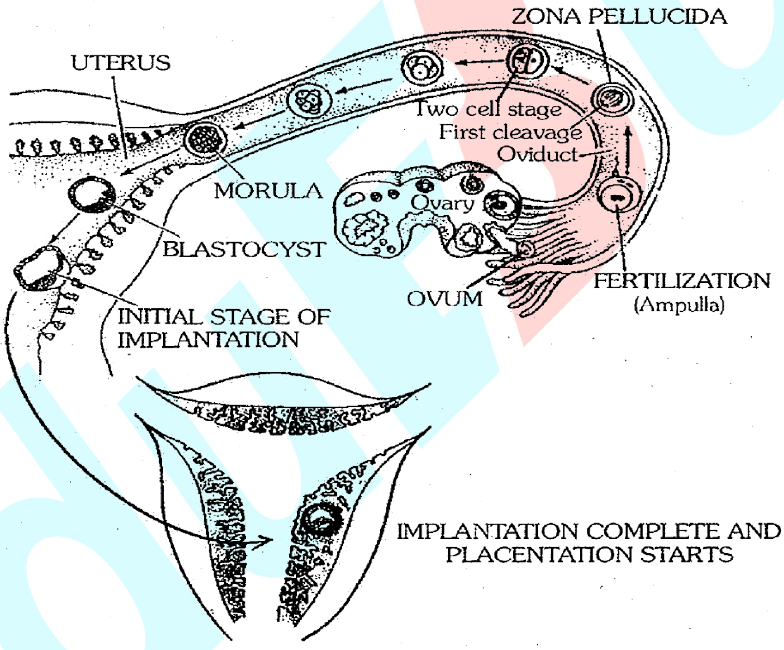
The blastomeres in the blastocyst are arranged into an outer layer called trophoblast and an inner group of cells attached to trophoblast called the inner cell mass. The trophoblast layer then gets attached to the endometrium and the inner cell mass gets differentiated ~s the embryo.



[Blastocyst]

IMPLANTATION



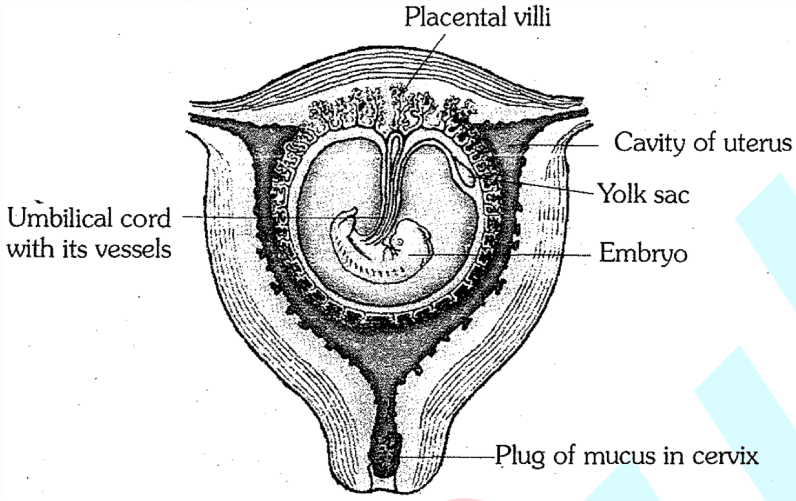


Mechanism of Implantation

Initially the oocyte after its release from ovary, comes into fallopian tube where the process of fertilization is completed. Just after fertilization, embryonic development starts and a blastocyst is formed after cleavage and morulation. In human being, the blastocyst gets attached with the uterine endometrium in about four days after entering in uterus. At the same time, the cells of endometrium of implantation area separate out and adhere with embryonic cells with the help of certain enzymes secreted by the cells of trophoblast. In human, the site of implantation is generally mid-dorsal/fundus part of uterus. Implantation of blastocyst takes about 7-8 days after fertilization in human and by 12^{th} day it is completely buried in the wall of the uterus. The place of entry through which the embryo enters into the wall, is completely closed by a fibrous and cellular plug, known as **closing coagulum.**

Function of the zona pellucida - It prevent implantation ·of the blastocyst at an abnormal site.

The trophoblast has the property of being able to stick to the uterine (or other) epithelium and its cells have the capacity to eat up other cells.



Interstitial implantation- The blastocyst is buries deeply inside the wall of uterus and covered by the endometrial tissues lying under epithelium. This type of implantation occurs in human being.

After implantation endometrium is known as decidua.

GASTRULATION

Gastrula : In gastrula stage rate of cleavage division is slow and ultimately stops at the end of gastrula. Gastrula stage is the most important stage in embryonic development because two main events take place during gastrula stage.

(a) Differentiation of blastomere: As a result of differentiation of blastomere; three germinal layers i.e. ectoderm, mesoderm and endoderm are formed. Formation of three germinal layers is the significance of gastrula stage. All the preparation of differentiation of blastomere are completed in late blastula stage.

(b) Morphogenetic Movements: During gastrula stage blastomere perform amoeboid movement and reach to their definite place in embryo because after the gastrulation organogenesis has to start in embryo. Morphogenetic movement requires enormous energy. So respiratory activity of egg increases.

Method of Gastrulation :

(a) Epiboly : Movement of ectoderm forming blastomere

(b) Emboly : Movement of mesoderm and endoderm forming blastomere.

In same animals new cavity if formed in gastrula this is called gastrocoel or archanteron cavity.

Immediately after implantation, the inner cell mass (embryo) differentiates into ectoderm endoderm and mesoderm (between the ectoderm and the endoderm). These three layers give rise to all tissues (organs) in adults. It needs to be mentioned here that the inner cell mass contains certain cells called stem cells which have the potency to give rise to all the tissues and organs.

Summary of developmental stages in human

- After one month of pregnancy, the embryo's heart is formed .
- By the end of the second month of pregnancy the foetus develops limbs and digits .
- By the end of 12 weeks (First trimester), most of the major organ system use formed.
- The first movements of the foetus and appearance of hair on the head are usually observed during the fifth month.
- By the end of 24 weeks (Second trimester), the body is covered with fine hair, eye-lids separate and eye lashes are formed.
- By the end of nine months of pregnancy, the foetus is fully developed and is ready for delivery.

EXTRA EMBRYONIC MEMBRANES AND PLACENTA

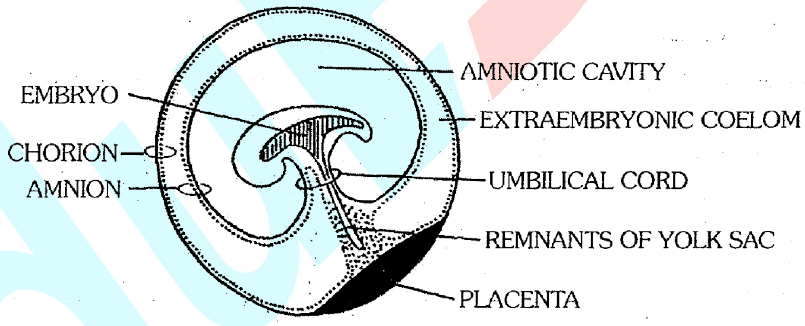
Extraembryonic membranes

The cellular layer formed of blastomeres remains as blastoderm. The central part of blastoderm gives rise to embryo proper, while the peripheral portion does not take part in the formation of embryo. This peripheral part is known as extra embryonic region. This .region takes part in the formation of certain membranes called extra embryonic membranes. These extra embryonic membranes provide facilities for nutrition, respiration and excretion to the embryo. Extra embryonic membranes are of four types-

1. Amnion 2. Chorion 3. Yolk sac 4. Allantois

On the basis of presence or absence of amnion, two groups of vertebrates are categorised-

1. **Amniota-** This group is characterized with the presence of amnion in the embryos of its members. For example members of class Reptilia, Aves and Mammalia.
2. **Anamniota**- Animals of this group are devoid of amnion in their embryos. For example class cyclostomata, pisces and amphibia.



Formation of extraembryonic membranes in human

1. **Amnion-** With a gradual increase in size the amnion covers the embryo from all sides. After about eight weeks of fertilization, amnion is completely incorporated into connecting stalk, which finally forms the umbilical cord. Embryo, in this stage, is called as foetus remains hanging in amniotic fluid.
2. **Chorion-** After implantation of blastocyst, the trophoblast gives out several finger like processes, the chorionic villi which get embedded into uterine endometrium Mesoderm also contributes in the formation of these villi. After a period of four month these villi disappear from all parts except a disc like area where they grow rapidly and participate in the formation of placenta.
3. **Yolk sac-** Initially the size of yolk sac is larger as compared to that of the embryo. About eight weeks after fertilization, the yolk is reduced in size and changes into a tubular structure.
4. **Allantois-** The mesoderm of allantois forms many small blood vessels in this region. These vessels connect the embryo with placenta and ensure nutritional and respiratory

supply to embryo. In human, allantois does not function to store the excretory wastes as it does in reptiles, birds and protothians.

PIACENTA

The chorionic villi and uterine tissue become interdigitated with each other and jointly form a structural and functional unit between developing embryo (foetus) and maternal body called placenta.

The eggs of viviparous animals are unable to develop into their embryos outside the uterus independently. This is because of the very little or negligible amount of yolk present in these eggs, which can not fulfill the nutritional and other physiolgical demands of a developing embryo. Here the embryo depends upon maternal tissues for shelter, nutrition, respiration etc. These animals therefore, have developed adaptation, respiratory and other physiological requirements from mother's body.

Placenta is found in all viviparous (exept sub-class-prototheria; oviparous) animals.

Placenta is temporary endocrine structure which partially derive from maternal and embryonic tissue.

Chorio-allantoic placenta in mammals.

1. In this type of placenta, allantoic mesodern and the mesoderm of umbilical cord jointly form the blood vessels of umbilical cord. The endodermal part of the allantois remains as a very small cavity.
2. To obtain nutrition from maternal blood several finger like processes or villi are formed by chorion which penetrate deeply into the crypts of uterus. Initially the villi are scatterd over the whole surface of chorion but later they become restricted in the decidua basalis region. The chorionic villi on the remaining surface disappear shortly. The part of chorion, which helps in placenta formation is known as **chorionic frondosum.**

Classification of Placenta

On the basis of different characters, the mammalian placenta are classified in following manner-

1. **On the basis of intimacy**

   Deciduate placenta- This type of placenta is found in human, dog, hare etc. It is characterized with a very close association between chorionic villi and uterine wall. At the time of birth, the mucosal covering of the uterus is also damaged and discarded outside. This results in an extensive bleeding at child birth. This placenta is known as a true placenta.
2. **On the basis of implantation**

   Interstitial- This type of placenta is found in man, guinea pig, apes etc. The chorionic sac(placenta) penetrates deep inside the wall of uterus. Hence, the association between embryo and maternal part becomes very close.
3. **On the basis of distribution of villi**

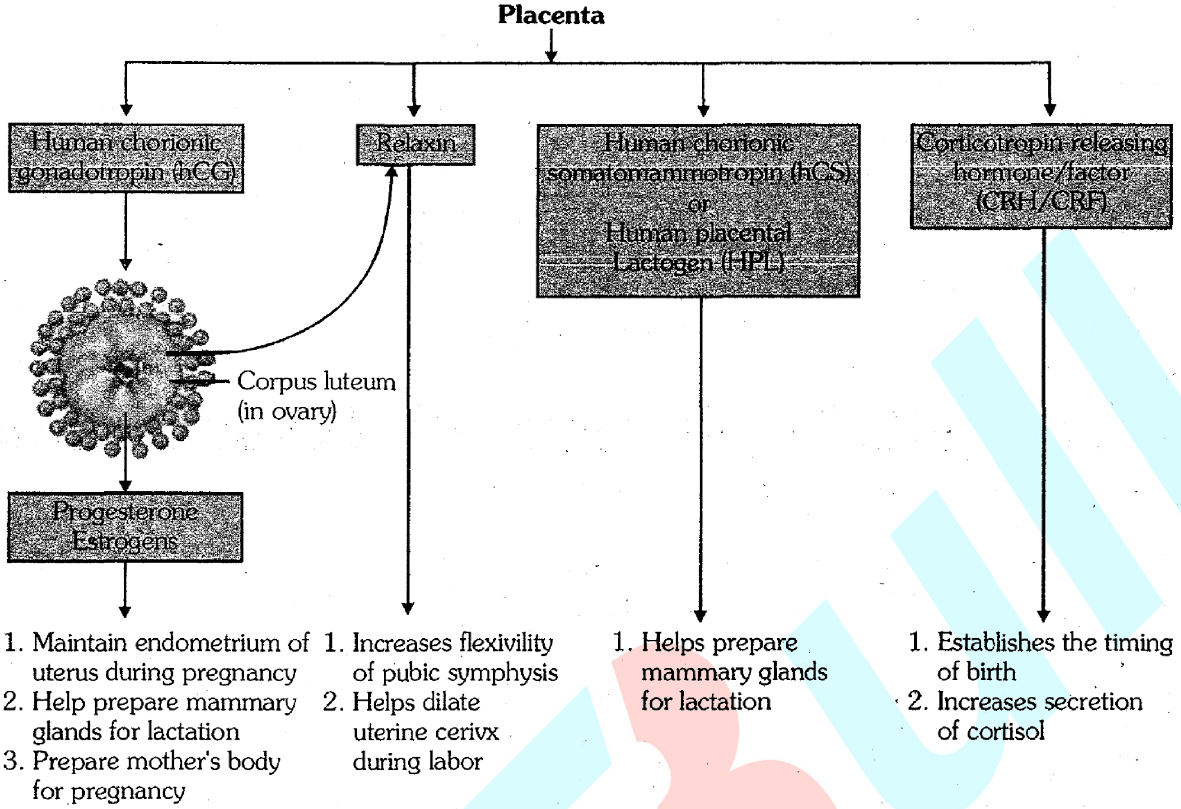
   Discoidal placenta- In this type of placenta, whole of the chorionic surface is covered by villi in initial stge, but the villi disappear later from most area except the region of implantation, that is only a disc like region is left with villi.

   Mono discoidal placenta- The villi are present only on dorsal surface in a single circular disc like area.

   For example- human, etc.
4. On the basis of histology : **Haemochorial**.

   eg. Human

<u>Honnones of Human Placenta:-</u>



Functions of placenta

1. Exchange of important materials between foetal and maternal blood.
2. The essential materials are exchanged by diffusion, pinocytosis or active transport.
3. The small molecules like O_2, CO_2, H_2O etc. are diffused through placenta.
4. The nutritional substances are supplied to embryo from the mother through placenta.
5. Placenta also serves as a respiratory medium for exchange of O_2 and CO_2 between embryo and mother.
6. The nitrogenous and metabolic wastes from foetus are released into the blood of mother by diffusion through placenta.
7. The antibodies for measles, chikenpox, polio etc. present in the blood of mother reach the embryo through placenta.
8. If a female takes some harmful chemicals (teratogens), liquor, drugs etc. during pregnancy, these may cross the placenta and on reaching into foetus may cause deformity during organogenesis. (eg. Thallidomide)
9. Placenta itself secretes some hormones like progesterone. estrogen. inhibin. hCG, hCS/HPL etc.
10. Progesterone, maintains and supports the foetus during the whole pregnancy period. At the time of parturition, relaxin is secreted by placenta which lubricates, and widens the birth canal to facilitate child birth.

PARTURITION

Parturition is a **complex neuroendocrine mechanism**. Many hormonal changes take place during it.

1. The progesterone secretion stops, so the placenta dissolves and_the foetus is separated from the walls of the uterus.
2. The signals for parturition originate from the fully developed fetus and the placenta which induce mild uterine contractions called **foetal ejection reflex.**
3. Pituitary gland secretes **Oxytocin** in more amount: This hormone induces intense contractions in the uterus. Due to these contractions, the foetus starts moving towards the vagina. The labour pain during child-birth, is due to this hormone. **Oxytocin is the main parturition hormone**. After parturition, Oxytocin stimulates milk-let down by **milk ejection reflex.**
4. **Relaxin** hormone is secreted by the placenta and the ovary of pregnant female. This hormone relaxes the pubic-symphysis i.e. the joint between the pelvic-girdles. So more space is available to the foetus to move out.

GOLDEN KEY POINTS

- After gastrulation, cleavage is completely checked. Nucleous appears first in gastrula stage. The consumption of oxygen is increased during cleavage.
- Embryo consumes maximum O_2 during gastrula stage.
- The part of decidua where placenta is formed is known as decidua basalis.
- During pregnancy the levels of other hormones like estrogens. progestogens. Cortisol, prolactin, thyroxine, etc.; are increased severalfold's in the maternal blood.
- Maximum growth in human embryo occurs in fourth month of pregnancy and minimum in last months.
- Pathogenic viruses may also enter in embryo through placenta.
- **Perianal glands**
  These are found both in male and female rabbits. Perianal gland is found around external genital organ & perineal region. During the breeding season, these glands secrete odoriferous liquid which has **pheromones** or **Ectohormones** in it. The pheromone develops sexual attraction between opposite sexes & also develops desire for copulation.
  Note :- In human, Perianal glands are absent.
- **Ectopic pregnancy :** Implantation of embryo on any site other than uterus.

BRIEF REVIEW

Development of secondary sex organ –

Male	Female
● Wolffian duct or Mesonephric duct- — Epididymis, Vas deferent, Seminal vesicle	● Mullerian duct – Fallopian tube, uterus and vagina (Oviduct)

Homologus organs		
	Male	**Female**
1.	Scrotal sac	Labia majora
2.	Penis	Clitoris

3.	Prostatic utricle	Vagina, Uterus
4.	Prostate gland	Paraurethral gland of Skene

Puberty-

The age of sexual maturity is called puberty.

- Accessory sex characters first appear in puberty
- Puberty occurs in girls at the age of 11 to 14 year
  Puberty occurs in boys at the age of 12-15 year

Changes in Puberty in boys and girls

		BOYS	GIRLS
1.	Gonadal	Enlargement of the testes, spermatogenesis begins	Ovarian cycle and ovulation begins
2.	Accessory Sexual Organ	Penis, prostate, seminal vesicles and epididymis grow in mass	Uterus, vagina, Fallopian tube, vulva increase in size. Endometrium shows menstrual changes and menstruation occurs.
3.	Hair and voice	Appearance of Beards, moustache, axillary, pubic & chest hair. Low pitch sound	Typical femine distribution of hair (axilla+pubis but no hair on chest or abdomen). Breast grows, fat deposition leading to feminine contours. High pith sound
4.	Somatic	Skeletal system- grows in length Muscular system- Grows in bulk & strength	Pelvic girdle becomes roomy and bigger than pectoral (opposite to boys, where pectoral girdle is bigger and pelvic much less roomy)
5.	Psychic	Attraction for girls begins.	Attraction for boys.
6.	Hormonal	FSH, LH and testosterone secretion – all rise.	FSH, LH, estrogen, progesterone secretion – all rise.

Vagina-

- The vagina is lined by a stratified squamous epithelium without any glands.
- During reproductive life the vagina contains lactobacillus acidophilus or doderlein's bacilli which keeps the vaginal pH between 4 to 5 by producing lactic acid from glycogen.

Gametogenesis-

Formation ·of gametes for sexual reproduction.

- Germ cells in vertebrate gonads are produced by both mitosis and meiosis.

Gestation period -

Duration between fertilization and Parturition.

(1) Rabbit= 28 – 32 days.
(2) Man = 270 – 290 days
(3) Dog = 60 – 65 days
(4) Cat= 62 – 72 days
(5) Elephant= 607 – 641 days

Gynaecomastia - Development of breast in the male.
Hysterectomy - Surgical removal of uterus.

Oopherectomy- Removal of ovaries.

Path of sperms in mammals -

- Seminiferous tubules → Rete testis → Vasa efferentia → Epididymis → Vasa deferens → Urinogenital Chamber → Urethra → Vagina.
- Use of antibiotics, smoking marijuana, alcohol, hot bath, high fever can also cause temporary drop in sperm count.

Spontaneous ovulator - Ovulation occurs without ~my induction. **Ex.** Most animals (Human)

Induced ovulator (Reflex ovulator) = ovulation occurs after copulation **Ex.** Rabbit.

Vesectomy - Cutting and tieing vas deferens.

Tubectomy (Salpingectomy) - Cutting and ligating fallopian tube.

- Colostrum is the first milk produced after child birth
- In contraceptive pills oestrogen and progesterone are present in variable combination.

Human sperm - 60Jllong, of this 5511 is the length of the tail.

- ln menstrual cycle proliferative phase is of 10-12 days and it is under the influence of oestrogen hormone.
- Luteal or secretory phase of menstrual cycle is of 14 days and it is under influence of progesterone hormone & It is always of fixed duration.

Testicle – Testis + Epididymis

- Epididymis is 3m long in rabbit while 6 to 8 m long in man.
- Function of epididymis = functional maturity and storage of sperms.

Os-penis or Baculum - Ossification occur in septum present between two corpora cavernosa.

1. In penis of some animals a bone is present called baculum and such a penis is called Os-penis e.g. i Whale, Bat, Rat etc. ~
2. The penis of opposum, Bandicoot etc. is double branched (Bifurcated).

Menarche - Begining of menstrual cycle in females.

- Size of human ovary–

Length	×	Width	×	hickness
2 to 4 cm		2 to 2.5 cm		1 to 1.8 cm

- Diameter of Graafian follicle– 1 to 1.5 cm.
- Fallopian tube length– 10 cm to 12 cm.

Hermaphroditism : Those animals who have both type of sex organs are called Hermaphrodite animals, it is found in tapeworms and earthworms.

Capacitation : Reactivation of sperm called capacitation. It is occurs in vagina. After ejaculation of sperm in vagina, cervical mucous secretory fluid dissolves inlibitory substances related to sperm & provide more energy to sperm.

SPECIAL POINTS

1. In human Gametogenesis, maturation phase is longest.
2. The acrosome of sperm are produced by golgibodies.
3. Formation of yolk in oogenesis takes place in the growth phase.
4. Largest egg is of Ostrich (16 cm long with its shell).
5. Although normal number of sperm are present in semen but if these are completely non motile. This condition is known as necrospermia.
6. Smallest egg in birds is of humming bird.
7. Due to high mortality rate in lower animals, the production of egg is more.
8. The life span of eggs in female reproductive organs in human being is 48 hrs.
9. At the age of 45-50 yrs. in female the ovulation process will stop which is known as menopause.

10. Egg store food in the form of yolk. Process of synthesis of yolk is called **Vitellogenesis**.
11. Development of animal of embryo from egg without fertilization is called parthenogenesis.

ANSWER KEY

BEGINNER'S BOX-1	**Que.**	1	2	3	4				
	Ans.	**1**	**1**	**1**	**2**				
BEGINNER'S BOX-2	**Que.**	1	2	3	4				
	Ans.	**3**	**2**	**1**	**2**				
BEGINNER'S BOX-3	**Que.**	1	2	3	4	5	6	7	8	9
	Ans.	**2**	**1**	**1**	**2**	**4**	**2**	**3**	**4**	**3**
BEGINNER'S BOX-4	**Que.**	1	2	3	4	5	6	7	8	
	Ans.	**2**	**1**	**2**	**3**	**3**	**3**	**2**	**3**	
BEGINNER'S BOX-5	**Que.**	1	2	3						
	Ans.	**2**	**3**	**2**						
BEGINNER'S BOX-6	**Que.**	1	2	3	4	5	6			
	Ans.	**3**	**3**	**3**	**2**	**1**	**2**			