HUMAN REPRODUCTION

Primary Sex Organs: = Sex organs which produce gametes and sex hormones.

- also called gonads.
  E.g. Testes of male and ovaries of female are the primary sex organs.
- Their function is under the control of FSH and LH (in female) / ICSH (in male) from anterior lobe of pituitary gland.
- Testes produce sperms and hormones testosterone. The hormone helps in the formation and maintenance of secondary sex organs (accessory male sex organs) and external sex characters.
- Ovary produces ova and hormones like oestrogens

Secondary Sex Organs: = Sex organs, glands and ducts which do not produce gametes and hormones but are otherwise essential for sexual reproduction. Secondary sex organs of human male reproductive system are vasa efferentia, epididymes, vasa deferentia, ejaculatory ducts, seminal vesicles, Cowper's glands, Urethra, prostate gland and penis. Secondary sex organs of a human female reproductive system are fallopian tube, uterus, vagina, external genitalia, Bartholin's glands and mammary glands (Breasts).

Primary Sex Organs	Secondary Sex Organs
1. They are represented by gonads.	1. They are represented by sex organs, ducts and glands other than gonads.
2. They produce gametes.	2. They do not form gametes.
3. They have no role in conduction of gametes.	3. They are connected with conduction of gametes.
4. They produce sex hormones.	4. Hormone secretion is absent.
5. Their is controlled by hormones of anterior pituitary gland.	5. Function of secondary sex organs is controlled by gonads.

Human Male Reproductive System: It consists of following parts:

1. Scrotum: It consists of a pouch of deeply pigmented skin divided into two sacs. Each sac contains one testis. Scrotal sac filled with tissue fluid called hydrocoel. *Scrotal sacs act as thermoregulators and keep the testicular temperature 2^0 to 2.5^0C lower than the internal body temperature. This temperature is ideal temperature for normal spermatogenesis, as high abdominal temperature kills spermatogenic tissues.*

(Explanation, keep a space of half page)

Q. "Failure of testes to descend into the scrotum produces sterility". Why?

Q. Give reason why the Human testes are located outside the abdominal cavity.

- Cryptorchidism = failure of testes to descend from the abdomen into the scrotum.

2. Testes: Testes are primary sex organs in man. These are one pair, small sized (4 – 5 cm x 2.5 cm x 3cm), oval shaped, pinkish coloured primary sex organs of male. Under the stimulation of FSH, the testes descend into the scrotal sacs during the 7th month of development.

i) Protective Coverings (Tunicae): The testis is surrounded by three layers –

a) Tunica Vaginalis: Outer covering of the testis.

b) Tunica Albuginea: a fibrous covering surrounding the testis situated under tunica vaginalis.

c) Tunica Vasculosa: consists of a network of capillaries supported by delicate connective tissue which lines the tunica albuginea.

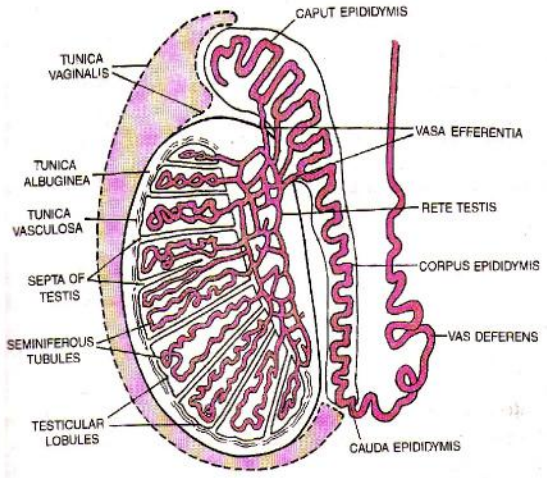


Fig: L.S. of mammalian Testis and different ducts

ii) Testicular Lobules:

Each testis consists of about 250 testicular lobules.

iii) Seminiferous Tubules: Each testicular lobule of testis contains one to three highly coiled seminiferous tubules. Each seminiferous tubule is lined by two types of cells – cuboidal germ cells (majority) and sertoli or nurse cells. The cuboidal cells undergo mitosis to produce spermatogonia.

Functions of Sertoli Cells or sustencular cells :

a) Sertoli cells secrete *androgen binding protein* (ABP) that concentrates testosterone in the seminiferous tubules.

b) Sertoli cells also secrete another protein called *inhibin* which suppresses FSH synthesis.
c) Sertoli cells provide nutrition to the developing sperms.
d) They cause controlled release of mature sperms into the lumen of seminiferous tubules (*spermiation*).
iv) Interstitial Cells or Leydig's cells: In between the seminiferous tubules in the connective tissue, there are present small groups of rounded interstitial or Leydig's Cells which secrete androgens (e.g. testosterone) i.e. male sex hormones.
v) Rete testis: The seminiferous tubules from different areas of a testis converge to form a network of interconnected tubes, the **rete testis**.
vi) Vasa efferentia: Vasa efferentia are fine ciliated ductules that arise from the rete testis. They vary from 15-20 in number and carry sperms from rete testis to the epididymis.

Functions of Testes:

i) Production of sperms.
ii) Secretion of male sex hormones.

(EXPLANATION, Keep a space of 1page)

3. Epididymes: It is loosely attached to the outside of testes. It is a long, narrow, highly coiled tubule which when straightened out measures approximately 6m. It is differentiated into three parts, *i.e.,* caput epididymis, corpus epididymis and cauda epididymis.
Functions: Epididymis is involved in storage of sperms (for 18 – 24 hrs), (also secretes a fluid which is considered to nourish the sperms) nutrition and physiological maturation of sperms.
Q. Where are sperms stored in male?
Ans:- Sperms are stored in epididymis.

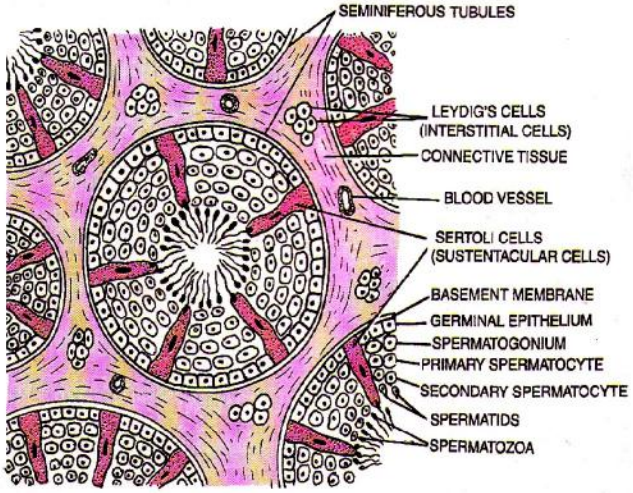


Fig: T.S. of Seminiferous tubule

4. Vasa deferentia: A vas deferens emerges from the cauda epididymis on each side and leaves the scrotal sac and loops over the urinary bladder where it is joined by duct from the seminal vesicle to form the *ejaculatory duct*.
Function: Vasa deferentia carry sperm.
5. Ejaculatory ducts: The ejaculatory ducts are two short tubes each formed by the union of the duct from a seminal vesicle and a vas deferens. They pass through the prostate gland and join the prostatic part of the urethra.
Function: Ejaculatory ducts carry sperms and secretion of seminal vesicles.

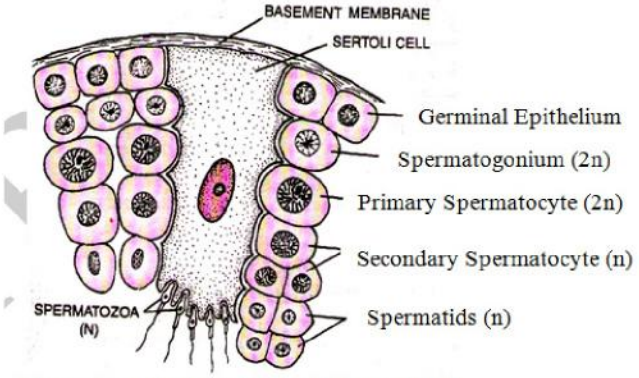


Figure: A sectional view of seminiferous tubule

(EXPLANATION, Keep a space of 1page)

Vasa Efferentia	Vasa deferentia
1. They arise from the rete testis.	1. They arise from the cauda epididymis.
2. They vary from 15 to 20 in number.	2. They are only 2 in number.
3. Vasa efferentia are fine.	3. Vasa deferentia are thick.
4. Their lining bears many cilia.	4. Their lining has many stereocilia.
5. It carries spermatozoa from rete testis to the epididymis.	5. It carries spermatozoa from cauda epididymis to the ejaculatory duct.

6. Urethra: It arises from the urinary bladder and joins the ejaculatory duct to form *urinogenital canal* as it carries urine, sperms and secretions of seminal vesicles, prostate and Cowper's glands.
Function: Conduction of sperms, secretions of accessory reproductive glands and urine.

7. Penis: It is erectile male copulatory organ which forms the external genitalia of male.

It is supported by three erectile tissues: out of the three columns two are dorsolateral, yellow fibrous ligamentous *Corpora Cavernosa*. The third is anterior, highly vascular and spongy *Corpus spongiosum* which surrounds the urinogenital canal.

Tip of penis is highly sensitive and is known as *glans penis*. It is covered by a retractile skin fold called *foreskin* or *prepuce*.

Function: i) Penis helps in copulation.

ii) Erection of penis is due to rush of arterial blood (about 10 times more) into the sinuses of corpus spongiosum aided by contraction of erector penis muscles.

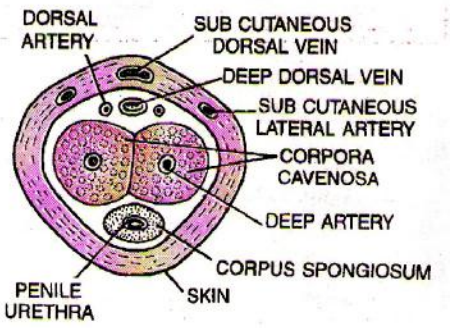


Fig: T.S. of Penis

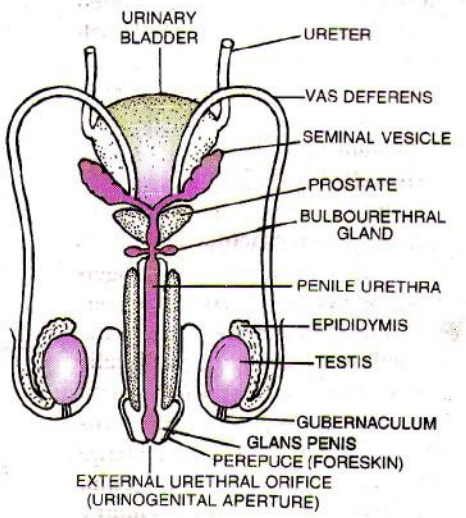


Fig: Front view of male reproductive system.

ACCESSORY (SECONDARY) GENITAL GLANDS OF MALE: These are of three types:

1. Seminal Vesicles:

– These are a pair of elongated (5 cm), muscular and sacculated glands situated in the pelvis between the bladder and rectum. The ducts of seminal gland join the vasa deferentia to form ejaculatory ducts.

Function: They produce an alkaline secretion that forms about 60-70% of the volume of semen.

Secretion of seminal vesicles-

– Fructose : Provide energy for the sperms.
– Prostaglandins : Stimulate uterine contractions that help the sperm to propel towards female's oviduct.
– Clotting proteins : Facilitates coagulation of semen after ejaculation.

2. Prostate Gland:

– It is a large, chestnut shaped spongy and lobulated gland which surrounds the proximal part of urethra. It pours its alkaline secretion into urethra by 20-30 openings.

Function : Prostate produces a slightly alkaline milky fluid, constituting 20-30% of the volume of semen. It contains citric acid, enzymes, bicarbonates. Its secretion nourishes and activates the spermatozoa to swim.

Secretion of prostate

– Citric acid : Acts as a nutrient for sperm.
– Enzymes : Like acid phosphatase, amylase, pepsinogen, etc.

3. Cowper's Glands or Bulbourethral Glands: These are a pair of small yellowed coloured glands present at the base of penis.

Function:

i) Prior to ejaculation, they secrete a mucous like substance that lubricates the penis for frictionless movement of penis during copulation.

ii) Its alkaline helps to protect the sperms from the acid present in male urethra and female vagina.

Onset of Puberty: Puberty is a period when reproductive organs start functioning.

In human male, it is characterized by the onset of spermatogenesis in testes.

Period: attained between 13 – 16 years.

Control: In male it is controlled by testosterone secreted by *interstitial cells or Leydig's cells* of testes.

(EXPLANATION, Keep a space of 1page)

HUMAN FEMALE REPRODUCTIVE SYSTEM: It consists of following parts:

1. Ovaries: Ovaries are the primary female sex organs that produce the female gamete (ovum) and several steroid hormones (ovarian hormones). The ovaries are located one on each side of the lower abdomen. Each ovary is covered by a layer of cubical epithelium called the *germinal epithelium*. It forms oogonia in the foetus. Each oogonium (egg mother cell) develops into *primary oocyte*. Each primary oocyte then gets surrounded by a layer of *granulosa cells* and is called *primary follicle*. No more primary follicles are formed and added after birth.

Every month, a primary follicle transforms into mature or *Graafian follicle* under the stimulation of FSH of anterior pituitary. A Graafian follicle consists of a secondary oocyte surrounded by Granulosa cells. Granulosa cells secrete a fluid (called *liquor folliculi)* which creates a large cavity called *antrum* or follicular cavity. It shifts the oocyte to one side. It is covered by its own plasma membrane also called *oolemma*. The follicular cells (Granulosa cells) are endocrine in function and secrete female sex hormones, *estrogens*, mainly estradiol in the blood. Under the stimulation of LH of anterior pituitary, *Graafian follicle* releases ovum on 14th day of menstrual cycle and transforms into yellowish, conical endocrine gland, *Corpus luteum*. LH stimulates corpus luteum to secrete a small amount of estrogen (estradiole) hormone and significant amounts of *progesterone* hormone. *Corpus luteum* also secretes *relaxin* hormone at the end of pregnancy. Degenerated part of the *Corpus luteum* is called *Corpus albicans*.

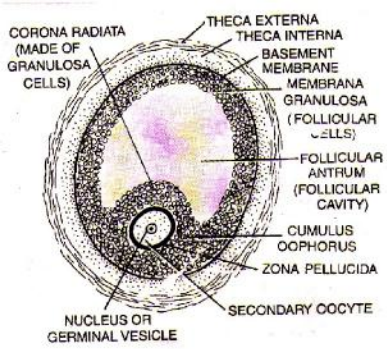


Figure: Mature Graafian follicle

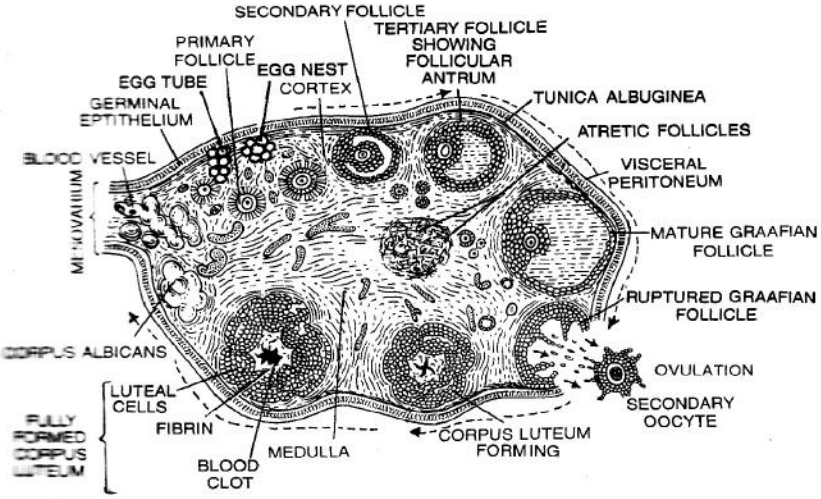


Fig: A section of a mature ovary

Functions: i) formation ova and ii) secretion of female sex hormones – estrogens and progesterone.

(EXPLANATION, Keep a space of 1page)

Graafian Follicle	Corpus Luteum
1. The follicle contains an ovum.	1. An ovum is lacking.
2. It has a cavity or antrum.	2. It contains a central blood clot.
3. The follicle secretes estrogen.	3. It secretes progesterone with little estrogen.
4. It grows under the influence of FSH.	4. It grows under the influence of LH.
5. It is formed during proliferative phase.	5. It is formed during secretory phase.

2. Fallopian Tubes (Oviducts): Each oviduct is about 10 -12 cm long and consists of the following parts:

I. The Infundibulum is a dilated trumpet – like portion opening into the peritoneal cavity. The end of the tube has finger like projections called *fimbrae*. There is a central fimbraeted apperture called *Ostium* which receives ovum released from the ovary.
II. The *ampulla* is the widest and longest part of the Fallopian tube.
III. The *isthmus* is the short, narrow thick – walled portion that follows the ampulla.
IV. The uterine part is inner and narrow part which opens in the upper part of uterus.

Functions:

i) Conduction of Ovum or Zygote towards the uterus by peristalsis and ciliary action.
ii) It is the site of fertilization (*ampulla – isthmus* junction).

(EXPLANATION, Keep a space of 1page)

3. Uterus (Womb): It is an inverted pear –shaped large distensible part of female reproductive system which is specialized for anchoring and nourishing the developing foetus. It is formed of three parts -

a) Fundus: It is upper dome – shaped part above the opening of fallopian tubes.

b) Body or Corpus: It is the middle and main part of uterus. Body of uterus is broad towards the fundus and narrows down towards the cervix.

c) Cervix: It is the lower, narrow part which opens in body of uterus by *internal os* and in the vagina below by *external os*.

Wall of uterus is formed of 3 layers-

i) Perimetrium: It is outer peritoneal layer;

ii) Myometrium: It is middle layer of smooth muscles which shows strong contraction during delivery of the baby and

iii) Endometrium: It is inner highly vascular and glandular mucosa.

Functions:

i) It is the site of implantation and foetal growth during pregnancy.

ii) It also takes part in the placenta formation and expelling of the baby during parturition.

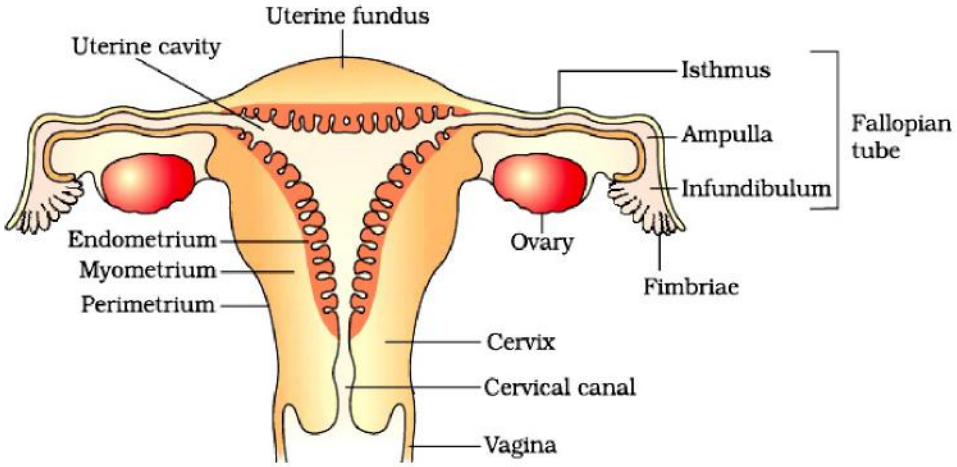


Figure: Diagrammatic sectional view of the female reproductive system

Endometrium	Myometrium
1. It is the inner glandular layer of the wall of the uterus. 2. It undergoes cyclic changes during menstrual cycle. Implantation of blastocyst takes on endometrium.	1. It is thick muscular middle layer of the wall of the uterus. 2. It is involved in the uterus movement.

4. Vagina:

The vagina is a tube like structure (about 10 cm long), that extends from the cervix to the outside of the body. It provides a passageway for the menstrual flow, serves as the receptacle for sperm during intercourse, forms part of the birth canal during labour. The opening of the vagina, called the vaginal orifice (vaginal opening) is partially covered by a membrane called *hymen*.

5. Vulva: The external genitalia are collectively called the vulva. It consists of following structures:

a) Mons Pubis: It is anterior most portion of external genitalia, which is a cushion of fatty tissue covered by skin and pubic hair.

b) Clitoris: It lies posterior to the mons pubis and is *homologous to the glans* penis of the male.

The *urethral orifice (urethral opening)* and *vaginal orifice* (vaginal opening) are present in the middle of the vulva.

c) Labia Majora: These are two large fleshy folds of skin which form the boundary of vulva. They are partly covered by pubic hair and contain large number of sebaceous (oil) glands.

d) Labia Minora: These are two smaller folds of skin, which lie under the labia majora. Labia minora provide covering to clitoris in front. They are fused posteriorly to form a frenulum or fold called *forchette*.

6) Mammary Glands or Breasts: At puberty in female mammary glands begin to develop under the influence of oestrogen and progesterone. Each breast has a broad multiporous *nipple* for the release of milk.

(EXPLANATION, Keep a space of 1page)

The glandular tissue of each breast is divided into 15-20 mammary lobes containing clusters of cells called alveoli. The cells of alveoli secrete milk, which is stored in the cavities (lumens) of alveoli. The alveoli open into mammary tubules. The mammary 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.

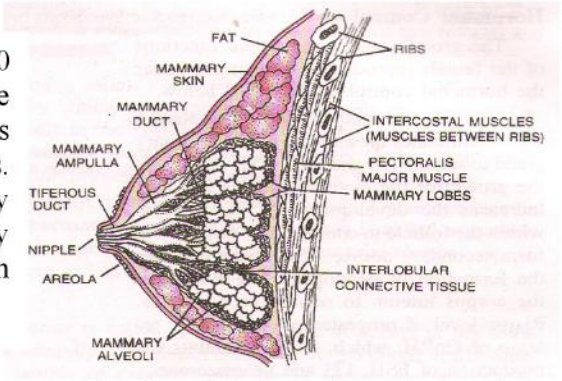


Fig: Female's breast in sagital section

Milk secretion occurs only after parturition. It is stimulated by *prolactin* hormone of anterior pituitary.

Onset of Puberty in Human Female: Puberty in female is characterized by the beginning of ovulation and menstrual cycle. Puberty in female comes between 10 to 14 years.

Control: Puberty in female is initiated by estrogen hormone.

Male Urethra	Female Urethra
1. It is much longer than (about 20 cm in length). 2. It has three regions: prostatic (3 – 4 cm), membranous (1cm) and penis (15 cm). 3. It opens out at the tips of penis by urinogenital aperture. 4. It carries both urine and semen.	1. It is short (about 4 cm in length). 2. It is not differentiated into regions. 3. It opens by urinary aperture in front of vaginal aperture. 4. It carries only urine.

GAMETOGENESIS: Gametogenesis is the process of formation and differentiation of haploid gametes (sperms and ova) from the diploid primary germ cells present in primary sex organs/gonads (testes in male and ovaries in female respectively)

Types: Gametogenesis is of two types: I. Spermatogenesis and II. Oogenesis.

SPERMATOGENESIS: It is the process of formation of haploid spermatozoa (= sperms) from diploid spermatogonia inside testes of male. It occurs in seminiferous tubules of the testes.

Spermatogenesis is a continuous process and is completed in about 74 days. It begins in human males during puberty and continues uninterrupted throughout the life of adult though it declines in later life.

Mechanism: Spermatogenesis is divided into following phases:

1. Multiplicative Phase: At sexual maturity, the undifferentiated primordial or primary germ cells divide several times by mitosis to produce large number of diploid and rounded *sperm mother cells* called *spermatogonia*. Some spermatogonia act as *stem cells* (called Type A spermatogonia which give rise to second type of spermatogonia whenever required). Type B spermatogonia are the precursors of sperms.
2. Growth Phase/Spermatocytogenesis: It is characterized by *spermatocytogenesis* in which a type B spermatogonium increases in size (about twice) by the accumulation of nutritive materials (derived from germinal cells and not synthesized) in the cytoplasm and replication of DNA, forms diploid *primary spermatocyte*.
3. Maturation Phase: Each primary spermatocyte (44+XY) undergoes two successive divisions, called maturation divisions. They undergo meiosis – I (reductional division) to produce small sized haploid secondary spermatocytes of two types, 22 + X and 22 + Y. Both secondary spermatocytes now undergo second maturation division which is an ordinary mitotic division to form four haploid spermatids, by each primary spermatocyte.

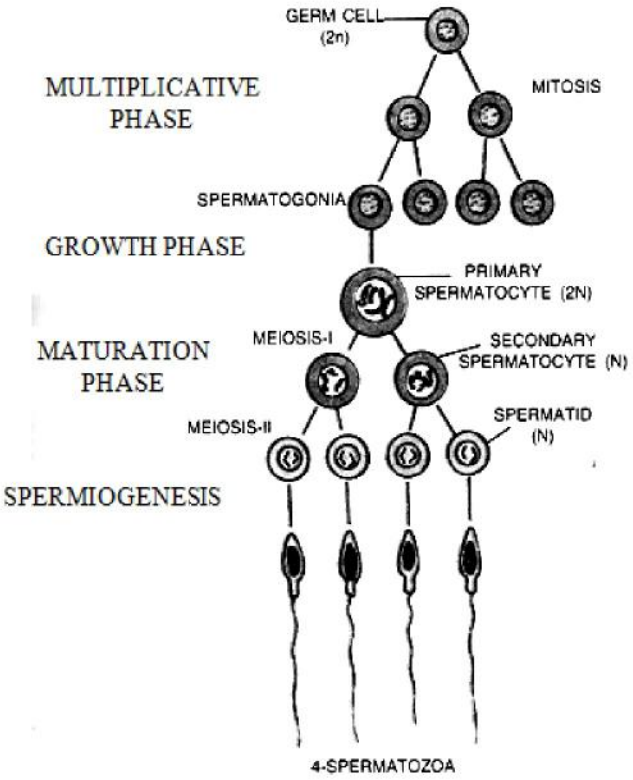


Figure : SPERMATOGENESIS

4. Spermiogenesis or Differentiation Phase (Formation of Spermatozoa): The transformation of spermatids into spermatozoa is called *Spermiogenesis* or *Spermateliosis*. During this phase, water is lost from the cytoplasm, acrosome is formed by Golgi apparatus, nucleus becomes elongated, axial filament is formed from distal centriole, mitochondrial spiral is formed around upper parts of axial filament.

(EXPLANATION, Keep a space of 2 pages)

SPERMIATION: After spermiogenesis sperms heads become embedded in the Sertoli cells and are finally released from the seminiferous tubules by the process called *Spermiation*.

Hormonal Control of Spermatogenesis:

- GnRH (Gonadotropin – releasing hormone) secreted by hypothalamus acts on the anterior lobe of pituitary gland to secrete FSH and ICSH/Luteinizing hormone (LH).
- FSH acts on spermatogonia to stimulate sperm production.
- ICSH/LH acts on the Leydig's cells of testes to secrete androgens like testosterone. Testosterone is essential for formation of sperms, at least spermiogenesis part by sertoli cells.

Significance:

1. During spermatogenesis, one spermatogonium produces four sperms.
2. Sperms have half the number of chromosomes. After fertilization, the diploid chromosome number is restored in the zygote. It maintains the chromosome number of the species.
3. Crossing over takes place during meiosis – I producing variations.
4. It occurs in various organisms. Thus, it proves the evidence of the basic relationship of the organisms.

(EXPLANATION, Keep a space of ½ page)

Spermatozoan (Sperm): Sperm is a microscopic, uniflagellate and motile haploid male gamete. It is basically formed of 4 parts:

a) Head: It is the enlarged end of a sperm, consisting of two parts – nucleus and a cap – like *acrosome*. Acrosome is derived from Golgi complex containing numerous enzymes called *sperm lysins* (e.g. *hyaluronodase, corona penetrating enzymes, zona lysins or acrosin*).

b) Neck: It is very short and is present between the head and middle piece. It contains the *proximal centriole* towards the nucleus (which plays a role in the first cleavage of the zygote) and the *distal centriole* which gives rise to the axial filament of the sperm.

c) Middle piece: It contains the mitochondria coiled round the axial filament called *mitochondrial spiral* (*nebenkern*). They provide energy for the movement of the sperm. At the end of the middle piece, there is a ring centriole (annulus) with unknown function.

d) Tail: It is the longest part of the sperm. The sperm swims about by its tail in a fluid medium.

VIABILITY: It is the period upto which the sperm is able to fertilize an ovum. It is only 1 to 2 days (24 to 48 hrs) for sperms.

Semen: The seminal plasma (secreted by seminal vesicles, prostate and cowper's glands) along with the sperms constitute the **semen**. The functions of male sex accessory ducts and glands are maintained by the testicular hormones (androgens).

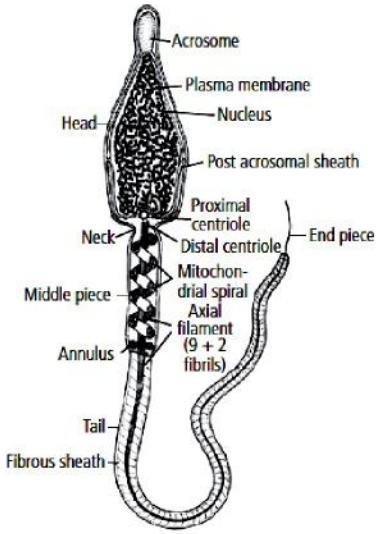


Fig: A mammalian Spermatozoon (as seen under electron microscope)

Q. What do you mean by seminal plasma?

Q. What is semen? What are the components of semen?

(EXPLANATION, Keep a space of 1page; Do not draw diagram before explanation, let's draw together)

OOGENESIS: It is the process of formation of functional haploid ova from the diploid germinal cells in the ovary or female gonad. In human female, Oogenesis is initiated in foetal stage (10th week of foetal life).

It consists of three phases: multiplication, growth and maturation.

1. Multiplication Phase: Certain cells in the germinal epithelium of the foetal ovary undergo rapid mitotic divisions to form diploid groups of diploid *egg mother cells, oogonia*. No more oogonia are formed or added after birth.
2. Growth Phase: This phase is of very long duration and extends over many years. It happens after puberty. During growth phase, One oogonium grows in size by taking food from surrounding follicle cells and functions as primary oocyte.
3. Maturation Phase: In this, the diploid primary oocyte undergoes meiosis I (reductional division) to form two unequal haploid daughter cells – a large *secondary oocyte* and a very small *first polar body* or polocyte.

The secondary oocyte again undergoes meiosis II (equational division) to form a large *ootid* and a very small second polar body. The ootid grows into a functional ovum. Meanwhile, the first polar body may divide into two.

In human female, the ovulation occurs at secondary oocyte stage in which meiosis-I has been completed and first polar body has been released. Meiosis – II is completed in the mother's oviduct usually after the sperm has entered the secondary oocyte for fertilization.

So, in oogenesis, a diploid oogonium forms one ovum and 2 or 3 polar bodies.

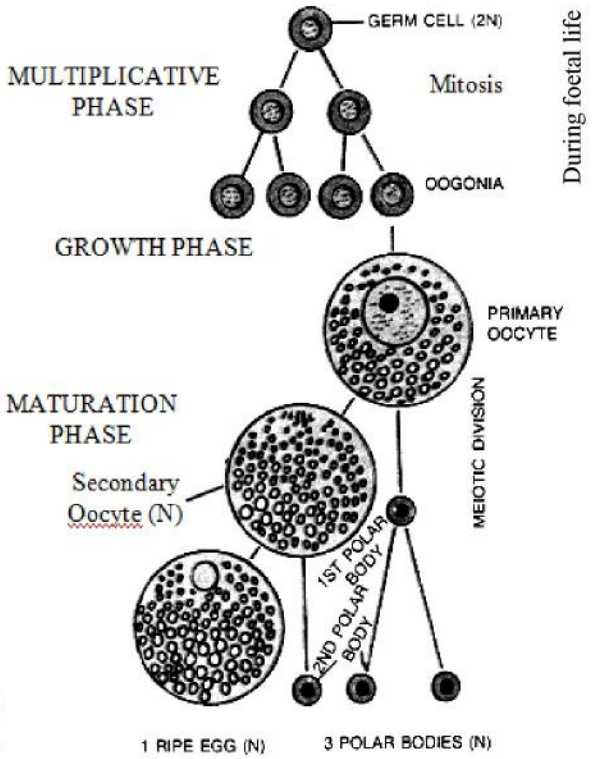


Figure : Oogenesis

Significance of Oogenesis:

1) One oogonium produces one ovum and three polar bodies.
2) During meiosis I crossing over takes place which brings about variation.
3) Polar bodies have small amount of cytoplasm. It helps to retain sufficient amount of cytoplasm in the ovum which is essential for the development of early embryo. Formation of polar bodies maintains half number of chromosome in the ovum.

(EXPLANATION, Keep a space of 2 pages)

OVULATION: The process of release of ovum (at secondary oocyte stage) from the ovary by rupturing the wall of ovary is called *Ovulation*. In humans ovulation generally occurs on the 14th day of the menstruation cycle. It is induced by LH.

Spermatogenesis	Oogenesis
1. It occurs inside testes.	1. It occurs in the ovaries.
2. All stages are completed inside testes.	2. Major part of oogenesis occurs inside ovary but last stages occur inside oviduct.
3. It is a continuous process.	3. It is discontinuous process (with early stages taking place in the foetus and the rest later in life.)
4. Growth phase is short.	4. Growth phase is prolonged.
5. No polar body is formed.	5. Polar bodies are formed.
6. A spermatogonium forms four spermatozoa.	6. An oogonium forms one ovum.

OVUM: Human ovum is rounded *non-cleidoic* (without shell) and *alecithal* (without yolk).

Its cytoplasm is called *ooplasm* containing large *nucleus*, termed the *germinal vesicle*. There is no centriole in the ovum. The cytoplasm is enveloped by the *plasma membrane*. Very small vesicles called *cortical granules* are present under the plasma membrane. A narrow *perivitelline space* is present outside the plasma membrane. Just outer to perivitelline space is non-cellular *zona pellucida*; probably secreted by the follicular cells. Outer to the Zona pellucida there is very thick cellular *Corona radiata*. The side of ovum which extrudes polar bodies is termed *animal pole*. The opposite side is called *Vegetal pole*.

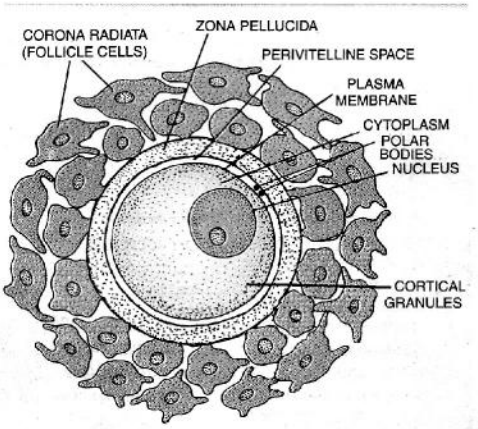


Fig: An Oocyte

(EXPLANATION, Keep a space of 1page; Do not draw diagram before explanation, let's draw together)

Sperm	Ovum
1. It is the male gamete.	1. It is the female gamete.
2. Sperm is motile.	2. Ovum is non-motile.
3. It contains a special cap called acrosome.	3. Acrosome like structure is absent.
4. It is externally differentiated into head, neck, middle piece and tail.	4. It is not externally differentiated into regions.
5. It has very small amount of cytoplasm.	5. It has a large amount of cytoplasm called *ooplasm*.
6. Mitochondria form a spiral in the middle piece.	6. Mitochondria are scattered in the ooplasm.

MENSTRUAL CYCLE: The cyclic changes that take place in the female reproductive system for gamete formation in certain primates (e.g. human beings), constitute *menstrual cycle*.

It is completed in 28/29 days (average) and absent during pregnancy and permanently stop at menopause. The menstrual cycle consists of four phases: menstrual phase, proliferative phase, ovulatory phase and secretory phase.

1. Menstrual Phase: It lasts for about 3 – 5 days (from 1st to 5th day). When ovum remains unfertilized, the corpus luteum starts degenerating. Progesterone levels in blood declines. The endometrium of uterus breaks down. The unfertilized ovum along with ruptured epithelium, blood and some mucus is discharged through vaginal orifice. This is called *menstrual flow or menstruation*.

2. Follicular (Proliferative) Phase: This phase lasts for about 8 – 9 days (from 6th to 13th day of menstrual cycle). It involves –

a) Increase secretion of FSH from anterior pituitary.

b) FSH stimulates the change of a primary follicle into a Graafian follicle.

c) Follicular cells of Graafian follicle secrete estrogen (estrogen level is maximum on 12th day) which have following effects –

i) Oestrogen stimulates growth, maintenance and normal functioning of secondary sex organs.

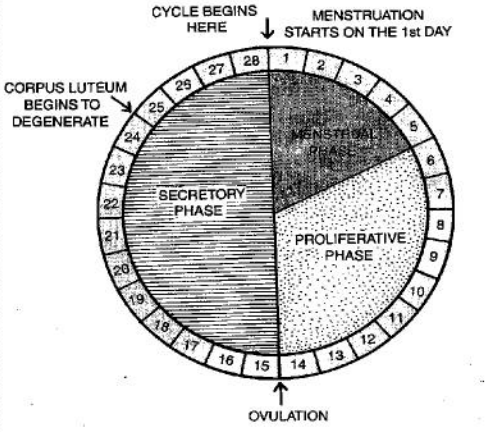
ii) Uterine endometrium becomes thick and prepares it for implantation.

iii) Fallopian tubes become thick and densely ciliated to conduct ovum/zygote.

iv) Oestrogen inhibits FSH secretion and stimulates secretion of LH from anterior pituitary.

3. Ovulatory Phase: Both LH and FSH attain a peak level in the middle of cycle (about 14th day). Sudden rise in LH induces rupturing of Graafian follicle and thereby the release of ovum (secondary oocyte). In fact LH causes ovulation.

4. Luteal Phase (Secretory Phase): It lasts for about 14 days (from 15th to 28th). Under the influence of LH the empty Graafian follicle develops into *Corpus Luteum* so is called luteal phase. The *Corpus Luteum* secretes large amount of progesterone and small quantity of estrogen.



Progesterone further proliferates or thickens the endometrium and is ready for implantation. High progesterone titre inhibits GnRH production from hypothalamus. In absence of GnRH, levels of FSH and LH fall.

In absence of fertilization, the corpus luteum degenerates. This causes disintegration of endometrium leading to menstruation marking a new cycle.

(EXPLANATION, Keep a space of 2 page; Do not draw diagram before explanation, let's draw together)

Proliferative Phase (Follicular Phase)	Secretory Phase (Luteal Phase)
1. During this phase, one primary follicle changes into Graafian follicle. 2. Oetrogens are secreted. 3. Endometrium is repaired and becomes 3mm thick.	1. It converts an empty Graafian follicle into Corpus Luteum. 2. Progesterone is secreted. 3. Endometrium grows further to become 5 – 6mm thick.

Q. What is menstrual Cycle? Which hormones regulate menstrual cycle?

MENOPAUSE: It is the period when ovulation and menstrual cycle stop in human female. It occurs between the age of 45 – 55 years (Average 52 years).

It is characterized by hot flushes (sensation of warmth spreading from trunk to face) and FSH is secreted in urine.

Cause: Decline in oestrogens and progesterone level leads to menopause.

Menarche	Menopause
1. It refers to beginning of menstruation at puberty in primate/human females. 2. In human beings, menstruation begins at about 13 years of age. 3. It marks the beginning of reproductive phase.	1. It refers to stoppage of menstruation and menstrual cycle. 2. It occurs between the age of 45 – 55 years. 3. It marks the end of reproductive phase.

FERTILIZATION: The fusion of a haploid male gamete (sperm) and a haploid female gamete (ovum) to form a diploid zygote is called fertilization.

Site of Fertilization: In human beings, fertilization takes place mostly in the *ampulla* – *isthmus* junction of the oviduct (Fallopian tube).

Arrival of Sperms: Male discharges semen into the female's vagina close to the cervix during coitus. This is called *insemination*. A single ejaculation may contain 300 million sperms.

Movement of Sperms: Many sperms are killed by the acidity of female genital tract and many sperms are engulfed by the phagocytes of the vaginal epithelium so that only about 100 sperms reach the fallopian tube. Sperms swim in the fluid medium at the rate of 1.5 to 3 mm per minute to reach the site.

Capacitation of Sperms: It is the phenomenon of sperm activation by which the sperms develop the ability to fertilize ova. Capacitation develops in the female genital tract. It takes about 5 to 6 hours for capacitation.

PHYSICAL AND CHEMICAL EVENTS OF FERTILIZATION: These events include the following processes.

1. Acrosomal Reaction: In contact with the surface of egg covering, the acrosome releases its contained hydrolytic enzymes, also called *sperm lysins*. These enzymes dissolve egg covering. It is known as *acrosomal reaction*. [Important sperm lysins are i) *hyaluronidase* that acts on the ground substance of follicle cells, ii) *corona penetrating enzymes* that dissolves corona radiata and iii) *zona lysins* or *acrosin* that helps to digest the zona pellucida].

2. Sperm Entry: At the point of contact with the sperms, the secondary oocyte forms a projection termed *the cone of reception* or *fertilization cone* which receives the sperm. Membranes of Sperm and egg dissolve at the point of contact. Components of sperm - nucleus and neck (proximal centriole) enter the cytoplasm of egg.

(EXPLANATION, Keep a space of 2 pages; Do not draw diagram before explanation, let's draw together)

3. Cortical Reaction: Just after the sperm entry, cortical granules are extruded beneath the plasma membrane of secondary oocyte and thicken. It is now called *fertilization membrane*. Fertilization membrane does not allow to enter second sperm

4. Karyogamy (Amphimixis): Sperm entry stimulates the secondary oocyte to complete suspended meiotic – II.

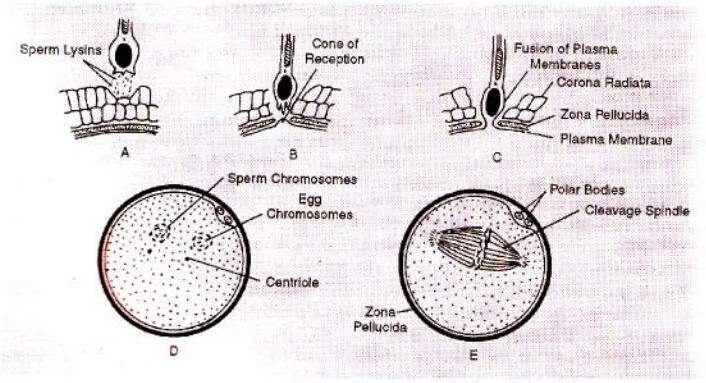


Fig: Stages of fertilization.

Significance of Fertilization:

1. It provides the stimulus for completion of meiosis II.
2. The diploid chromosome number is restored.
3. It determines the sex of the baby, depending upon the chromosome complement of the fusing sperm.
4. It combines the characters of two parents.
5. Fertilization membrane developed after the entry of sperm prevents the entry of other sperms into the ovum.

SEX OF THE BABY: Sex of the baby is determined at the time of fertilization. Women do not have any role in determining the sex of the child. They are homogametic producing only one type of ova (22+X). Men are heterogametic producing two types of sperms, *androsperms* (22+Y) and *gynosperm* (22+X) in equal proportion. Sex of the baby will be determined whether an androsperm or gynosperm causes fertilization. The chances are 50:50.

Q. In our society the women are often blamed for giving birth to daughters. Can you explain why this is not correct?

CLEAVAGE: It is a series of rapid mitotic division of the zygote which converts the single celled zygote into a multicellular structure called blastula (blastocyst). The resultant cells are called **blastomeres**. During early cleavages, the young embryo is moving down the fallopian tube towards the uterus.

MORULA STAGE: Morula is the stage of embryo which looks like little mulberry with a solid ball of cells. It has 8 – 16 cells, occasionally 32 cells. There is an outer layer of smaller, clearer cells around an inner mass of larger cells. The morula reaches the uterus in 4 – 6 days after fertilization. It is surrounded by *zona pellucida*.

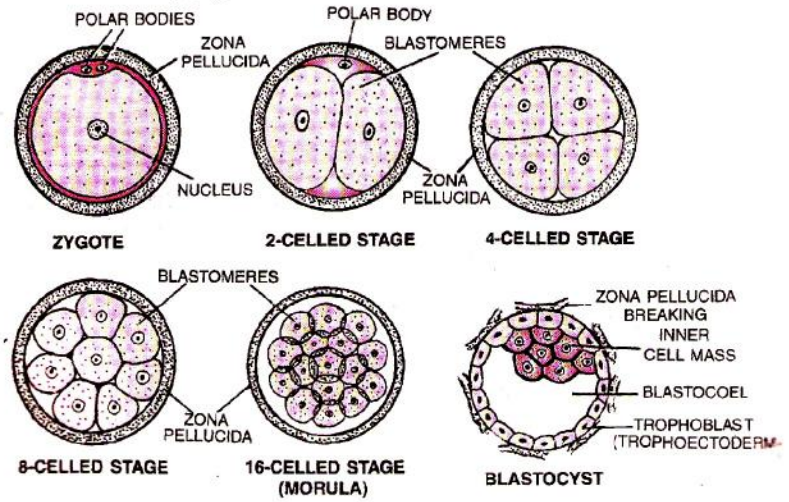


Fig: Early Stages of embryonic development

BLASTOCYST FORMATION: As the morula enters uterus, it obtains enriched supply of nutrients. Therefore, there is spurt in growth. Outer peripheral cells enlarge, flatten further and form trophoblast. The fluid absorbed by the trophoblast collects in a cavity, the blastocoel. The inner cell mass now comes to lie on one side. The cells of trophoblast which are in contact with the cell mass are called *cells of Rauber*. The inner cell mass is the precursor of the embryo which gives rise to the embryo and hence called stem cells or embryonal knob.

The cells of trophoblast help to provide nutrition to the embryo. The trophoblast does not take part in the formation of embryo proper. It remains external to the embryo and gives rise to the extraembryonic membranes.

As the blastocyst is formed, zona pellucida becomes thinner and finally disappears. This stage is now called the blastocyst.

(EXPLANATION, Keep a space of 2pages; Do not draw diagram before explanation, let's draw together)

Morula	Blastula
1. It is a solid sphere of cells formed by the cleavage of the zygote. 2. Zona pellucida remains intact. 3. At this stage, embryo moves from fallopian tube to uterus. 4. It is formed of 2 types of cells outer micromeres and inner macromeres.	1. It is a hollow sphere of cells of the blastomeres. 2. As the blastocoel enlarges, zona pellucida disintegrates. 3. Implantation occurs at this stage. 4. Formed of outer nutritive layer trophoblast and an inner cell mass, embryonal knob.

IMPLANTATION: Implantation is the attachment of the blastocyst to the uterine wall. The cells of the trophoblast layer form finger like structures called chorionic villi which penetrate into the infoldings of the uterine wall for organic connection between the embryo and mother's body.

Placenta: Placenta can be defined as a structure produced by the fusion of chorionic villi of the foetus with the uterine endometrium to serve the purpose of physiological exchange of materials between foetus and the mother.

Because the chorion takes part in the formation of placenta, the human placenta is called the *Chorionic placenta*.

After implantation, finger-like projections appear on the trophoblast called Chorionic villi which are surrounded by uterine tissue and maternal blood. The chorionic villi and uterine tissue become interdigitated with each other and jointly form **placenta.**

FUNCTIONS OF PLACENTA:

1. Nutrition: All the nutrient elements from the maternal blood pass into the foetus through placenta.
2. Respiration: Placenta helps in the exchange of respiratory gases (O_2 from mother and CO_2 from foetus) between foetus and mother.
3. Storage and Digestion: Placenta stores fat and glycogen which can be broken down and absorbed in the foetal part of placenta.
4. Excretion: Foetus eliminates its nitrogenous and other wastes through placenta.
5. Antibodies: Placenta is permeable to antibodies of the mother which enter the foetal blood and protect the foetus from several diseases.
6. As Barrier: Placenta does not allow passage of pathogens and toxins from entering the foetus.
7. Endocrine Function: Placenta secretes a number of hormones such as oestrogens, progesterone, human chorionic gonadotropin (HCG), human chorionic somatomammotropin (HCS), chorionic corticotrophin, chorionic thyrotropin and relaxin.

GASTRULATION: It is the process in embryonic development which is characterized by movement of cells in small masses or sheets so as to form primary germinal layers. The cell movements that occur during gastrulation are called morphogenetic movements. There are three primary germ layers – endoderm, ectoderm and mesoderm.

Blastulation	Gastrulation
1. There are rapid mitotic divisions of zygote. 2. Cells do not move. 3. A single layered hollow blastula (blastocyst) is formed.	1. There are slow mitotic divisions in the blastula (blastocyst) 2. The cell masses show morphogenetic movements. 3. A 3-layered gastrula is formed.

Embryo and Foetus: The term embryo is restricted to the stage before start of organogenesis, i.e. upto eight week. The term foetus is used thereafter upto birth of baby.

Pregnancy: Pregnancy is the time from conception to birth. It is approximately 9 months ± 7 days which is called gestation period.

IMPORTANT DEVELOPMENTAL CHANGES IN THE HUMAN EMBRYO:

The human pregnancy lasts 9 months. In human beings, after one month of pregnancy, the embryo's heart is formed. The first sign of growing foetus may be noticed by listening to the heart sound carefully through the stethoscope. 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 systems are formed, for example, the limbs and external genital organs are well-developed. 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 eyelashes are formed. By the end of nine months of pregnancy, the foetus is fully developed and is ready for delivery.

PARTURITION: It is the process of expelling of the full termed young one from the mother's uterus after the gestation period. (9 months ± 7 days).
Process: The signals for child birth (parturition) originate from the fully matured foetus and placenta which induce mild uterine contraction called *foetal ejection reflex*. This causes quick release of *oxytocin* from the maternal posterior pituitary gland. The amount of *oxytocin* is increased just before and during *labour pains* (pains of child birth). Oxytocin promotes contraction of the uterine muscles. *Relaxin* increases the flexibility of the pubis symphysis and helps to dilate the uterine cervix during labour pains. Both of these actions give relief to the body from the pain during delivery of the baby.

(EXPLANATION, Keep a space of 1page)

Q. From where do the signals for parturition originate and what does maternal pituitary release for stimulating uterine contractions for child birth?
Ans:- Signals for parturition: Fully formed foetus and placenta. Maternal pituitary releases oxytocin (in increasing quantity).
Q. What is parturition? Which hormones are involved in induction of parturition?
LACTATION: Production of milk in the mammary glands is called lactation.
Period: Though lactation starts towards the end of pregnancy but free flow of milk occurs only after the child birth.
Role of Hormones: Synthesis of milk by alveolar epithelium of mammary glands and its passage through the duct system is regulated by *prolactin hormone* of anterior lobe of pituitary gland. However, ejection of milk is stimulated by the hormone *Oxytocin* (OT) from the posterior lobe of pituitary gland.

COLOSTRUM: The first milk which comes from mammary glands of the mother just after child birth, 2 or 3 days is called the c*olostrums*. The yellowish fluid contains antibodies (Ig A is the major immunoglobulin in it) that provide passive immunity to the new born infant. Breast-feeding during the initial period of infant growth is recommended by doctors for bringing up a healthy baby.

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