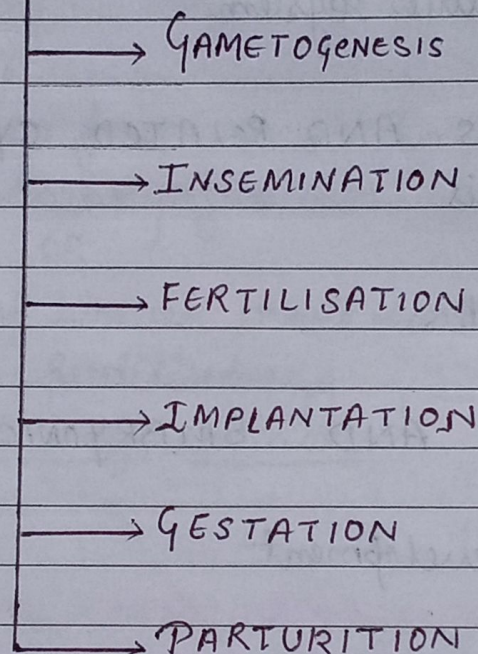


HUMAN REPRODUCTION

TOPICS IN THIS CHAPTER

- REPRODUCTIVE SYSTEM
 - Male Reproductive System
 - Female Reproductive System
- GAMETOGENESIS AND RELATED CYCLES
 - Spermatogenesis
 - Oogenesis
 - Menstrual cycle.
- FERTILISATION AND EMBRYONIC DEVELOPMENT
 - Fertilisation
 - Embryonic development
 - Parturition
 - Lactation

⇒ REPRODUCTION :- It is the ability of living organism to produce a new generation of living individuals similar to themselves.

REPRODUCTION EVENTS IN HUMAN

- Formation of gametes i.e. sperm in males and ovum in females. known as Gametogenesis.
- Transfer of sperm into female reproductive tracts known as Insemination.
- Fusion of male and female gametes known as Fertilisation.

- o Formation, development and then attachment of blastocyst to the uterine wall known as Implantation.
- o Embryonic development known as Gestation.
- o Delivery of the baby known as Parturition.

⇒ PUBERTY :- It is the condition of being or the period of becoming first capable of reproducing sexually that is brought on by the production of hormones and the maturing of the reproductive organs (Such as the testes and ovaries).

- o The age at which puberty occurs often construed legally as 14 in boys and 12 in girls.
- o The changes in your body during puberty are caused by hormones which are chemicals produced in your body.
- o These hormones are like chemical messengers that cause the testicles or the ovaries to release other hormones.
- o All these hormones work together to start the changes in puberty.

CHANGES OCCUR DURING PUBERTY

⇒ IN FEMALES

- o During Puberty body produces two hormones- oestrogen and progesterone.

- Oestrogen causes your breast to grow.
- Oestrogen and progesterone control your menstrual cycle or period.
- Thick hair growth under armpits and genital area change in voice.

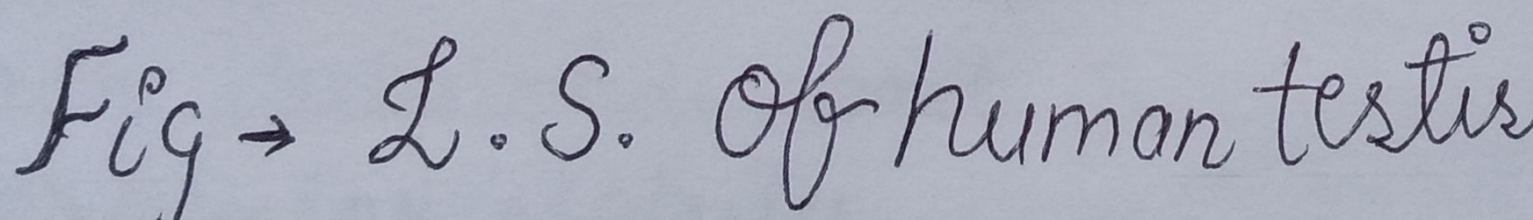
⇒ IN MALES

- The hormone testosterone is the hormone that starts development from boy to man.
- Testosterone is the major male sex hormone and it is produced in the testes.
- Testosterone starts the production of sperm, causes the chest and shoulders to broaden and causes facial hair to grow.

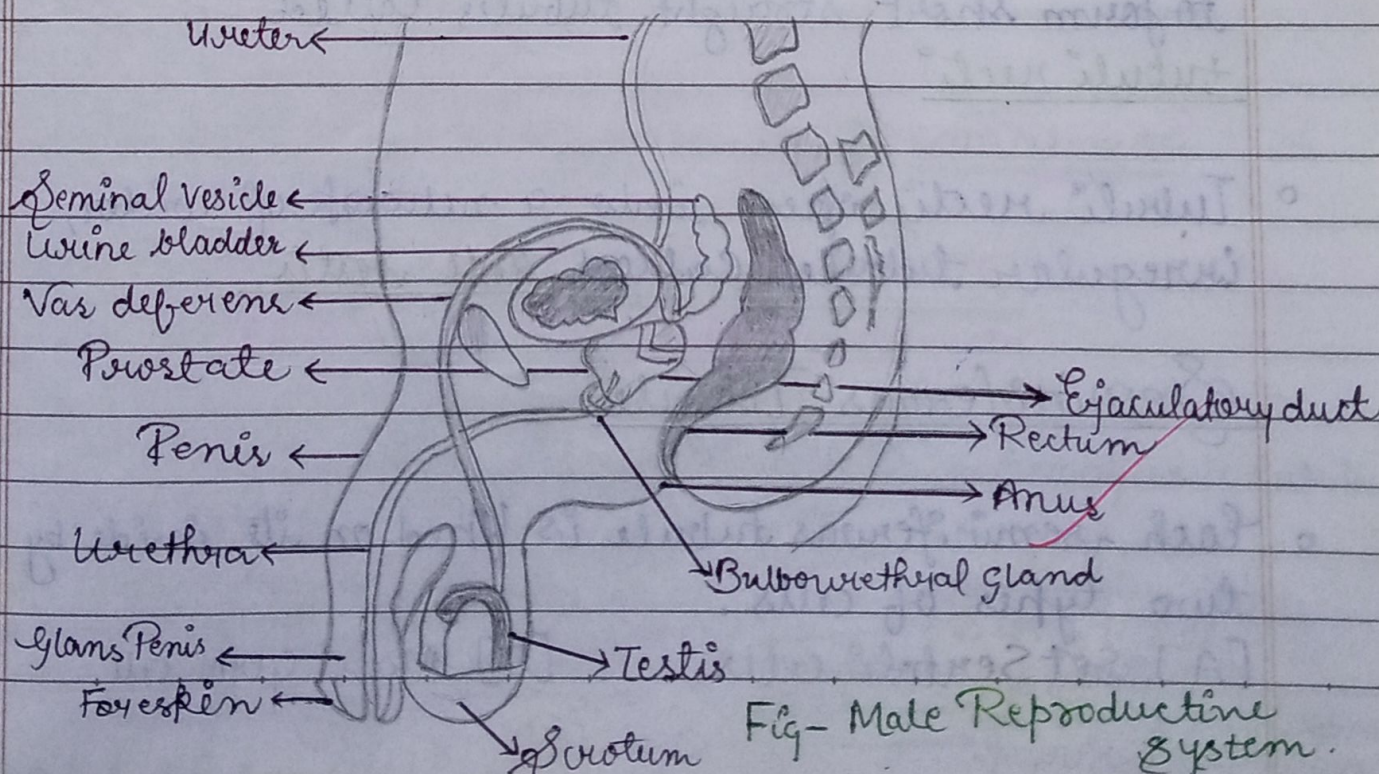
Male REPRODUCTIVE System

1. PRIMARY SEX ORGANS

- Testes are the primary sex organs in man.
- Testes is the site where the male gametes or sperms are made.



- The testes are situated outside the abdominal cavity within a pouch called Scrotum.
- In adult, each testis is oval in shape with a length of about 4-5 cm and 2-3 cm in width.
- Outermost covering of the testis is formed by a dense fibrous membrane called tunica albuginea.
- Each testis has about 200-300 compartments called testicular lobules.
- These compartments contain highly coiled tubules called Seminiferous tubules.
- Each lobule contains 1 to 4 seminiferous tubules in which the sperms are produced.
- Blood vessels and nerves are embedded in loose connective tissue.



Scrotum

- It is a pouch-like structure of pigmented skin arising from the lower abdominal wall hanging between the legs.
- Scrotum keeps the temperature of testes about $2-2.5^{\circ}\text{C}$ which is essential for the production of sperm to take place.
- It is divided internally into right and left scrotal sacs by a muscular partition called Septum Scroti.
- Testis originates in abdominal cavity but later the seventh month of development, descend into respective scrotal sac through passages called Inguinal Canals.
- End of seminiferous tubules converge & join to form short straight tubules called tubuli recti.
- Tubuli recti open into a network of wider, irregular tubules called Rete testis.

Seminiferous Tubule

- Each seminiferous tubule is lined on its inside by two types of cells.
[A] Sertoli cells [B] Male germ cell

Found in testis of Septa in 2 or 3 numbers.
* Structural & Functional unit of testis in which sperms are produced.

[A] Sertoli cells.

- Sertoli cells provide nutrition on the germ cells.
(Spermatogonia & spermatogenesis)
- Cuboidal cells produce spermatogonia by mitotic division, which grow into Primary spermatocytes.
- These undergo meiosis producing haploid cells.
- First Secondary Spermatocytes & then spermatids.
- The region outside the seminiferous tubules called Interstitial spaces contain small blood vessels & masses of cells called Interstitial cells or Leydig cells.
- These cells synthesise & secrete the testicular hormone called Androgens.
- Leydig cells are endocrine in function & regulate, maintain male sex characteristic.

[B] Male Germ cell.

Male Germ cell give rise to spermatozoa.

NOTE :- THE MALE REPRODUCTIVE SYSTEM is located in the pelvic region.

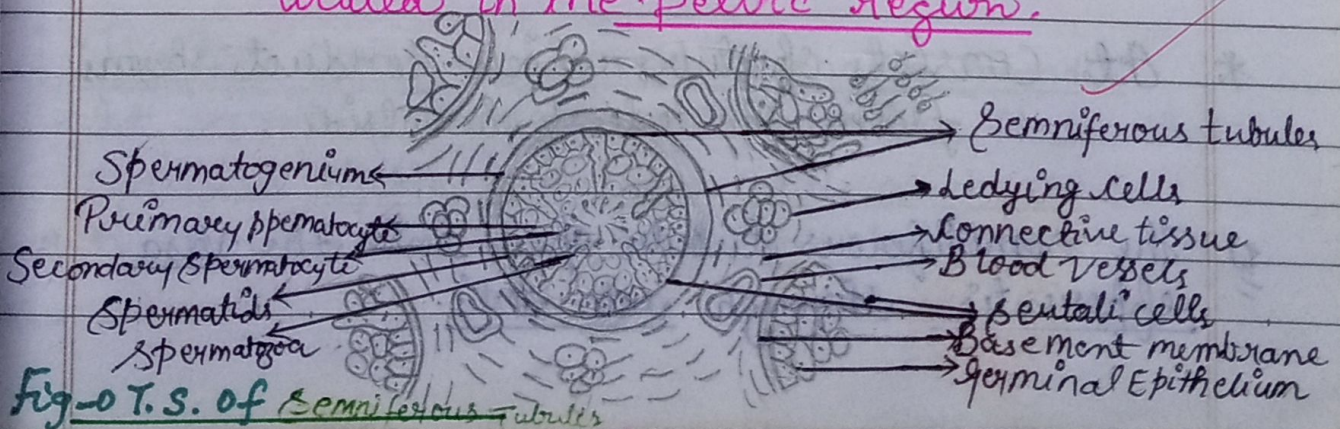


Fig-0 T.S. of Seminiferous tubules

KEY TERMS

- Testes :- Testes are present outside the abdominal cavity in Pairs.
- Scrotum :- Testes are situated outside the abdominal cavity within a pouch.
- Vasa efferentia :- It start with a duct with a duct from each testis.
- Epididymis :- 10 to 12 Vasa efferentia confluent to form a folded & coiled tube.
- Vasa deferens :- Epididymis store the sperm temporarily from epididymis, a partially coiled tube called vasa deferens ascend into the abdomen & passes over the urinary bladder.
- Urethra :- Male urethra provides a common pathway for the flow of urine and semen.

2 SECONDARY SEX ORGANS

(i) Accessory Duct System

- * It consists of tubes which conduct sperms from the testes to the outside.

- 1) The seminiferous tubules open into the Vasa efferentia through rete testis.

2. Several vasa efferentia open into the epididymis and carry sperm outside the testis.
3. Epididymis is a long, coiled tube present along the posterior surface of each testis. It continues as the vas deferens & ascends into the abdomen to loop over the urinary bladder. Epididymis temporarily stores non-motile & immature sperms.
4. The duct from seminal vesicle and vas deferens together form the ejaculatory duct. They pass through the prostate gland and join the urethra. They carry secretions of seminal vesicles & sperms from the testis to the outside through urethra.
5. Urethra originates from the urinary bladder & extends through the penis to its external opening called urethral meatus. It carries urine from the bladder and sperms from the vas deferens through the Penis.

* Sperms undergo physiological maturation acquiring increased motility & fertilising capacity i.e. Capacitation in epididymis.

ii) Accessory Glands

i) Prostate Gland :- (Chestnut shaped gland)

- It secretes a milky, slightly alkaline fluid that contains lipids, enzymes, citric acid etc.
- It is released during ejaculation.

- And. hyp. helps to neutralise the acidic medium of vagina.
- Making sperms more active to swim.
- Prostatic fluid accounts for nearly 20-30% of semen volume.

ii. Seminal Vesicles :- (Paired, situated behind bladder)

- They secrete mucus and watery ^{fluid} alkaline that contains Fructose (acts as an energy source for the sperms).
- Prostaglandins (stimulate uterine contractions for sperm movement)
- A clotting protein forms a temporary clot after ejaculation).
- Calcium and certain other enzymes are also a part of seminal plasma.

NOTE Fructose produced by seminal vesicles is not present elsewhere in the body. Therefore, during forensic test for rape, its presence in females's genital tract confirms sexual intercourse.

iii. Bulbourethral or Cowper's gland

- These secrete mucus and an alkaline fluid into the urethra.
- They are attached to the urethra below prostate gland.
- Mucus helps in lubrication of penis.
- Neutralises urinary acids if, present in urethra.

Semen

- The secretions of accessory sex gland & mucus are added to sperm to form seminal fluid or semen.
- Secretions have many functions.
- Provide medium for transmission of sperm.
- Nourish and activate sperms to keep them viable & motile.

Note one component of semen is 'Zinc', whose role in reproduction & source is unclear. But its concentration below certain level has been associated with infertility.

3. External Genitalia:

- Penis is the external copulatory organ in males.

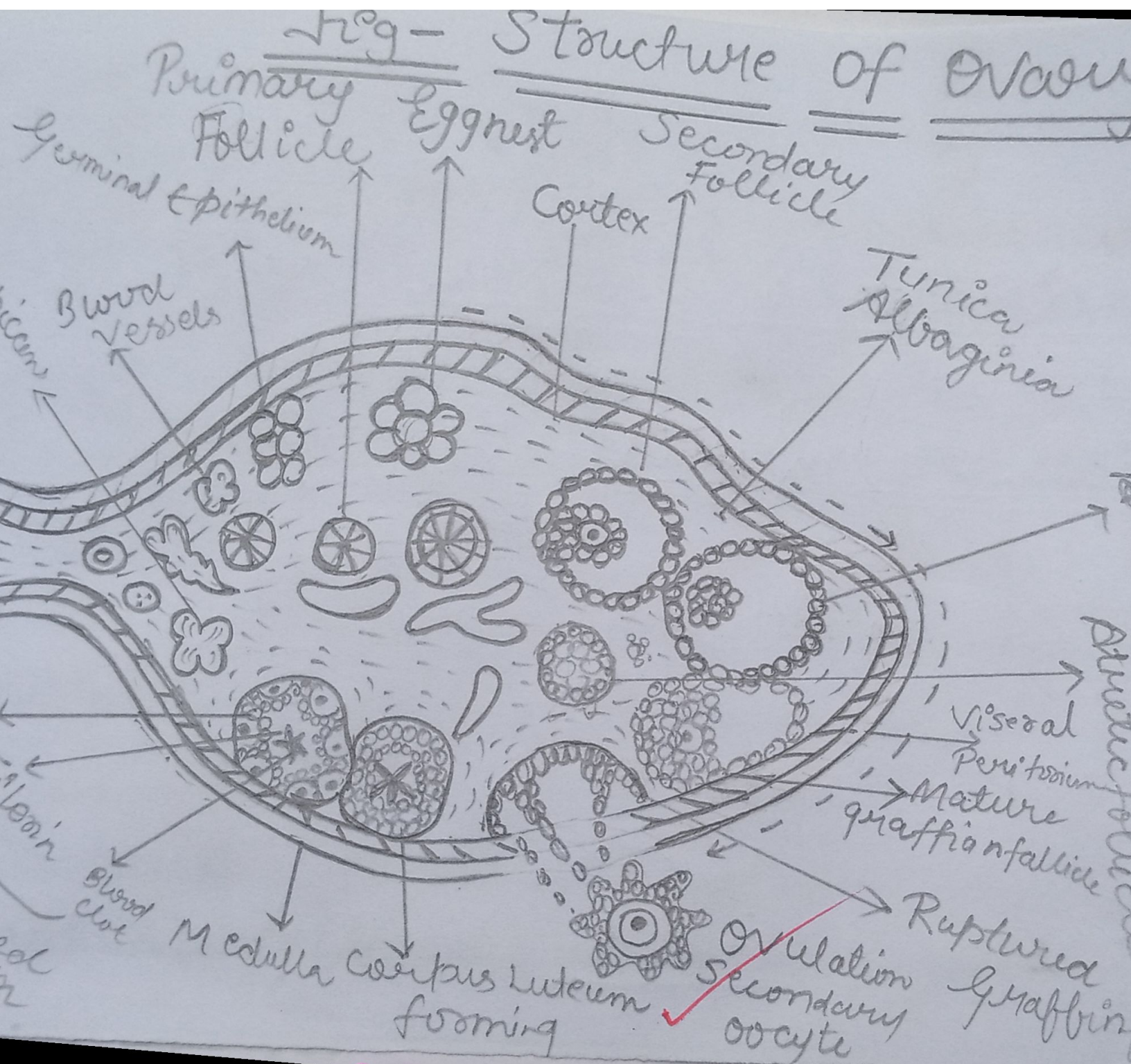
- Date: _____ Page: _____
- Near the tip of penis, the spongy tissue (Corpus spongiosum) is enlarged to form a soft & highly sensitive glans Penis. ✓
 - Covered with the foreskin or prepuce.
 - It has erectile tissues & vascular spaces.
 - The vascular spaces tend to fill up with blood.
 - When the male is sexually excited causing Penis to erect. ✓

FEMALE REPRODUCTIVE SYSTEM

1 PRIMARY SEX ORGANS

Ovaries are the primary sex organ of female. ✓

- Ovaries produce female gametes (ovum) & steroid hormones (ovarian hormones).
- Ovaries are almond-shaped lying in the lower part of abdomen held to the broad ligament by double folds of peritoneum called mesovarium.



- Each ovary is about 2-4 cm in length. Connected by an ovarian ligament to uterus by a suspensory ligament to the lateral pelvic wall.
- Each ovary covered by thin epithelium enclosing ovarian stroma.
- Contains connective tissue, blood vessels & mature follicles.
- Stroma divided into two parts, i.e. Peripheral Cortex and an inner medulla.
- Ovarian Cortex contains many rounded or oval bodies called Ovarian or Graafian follicles at various stages of development which ultimately give rise to ovum.

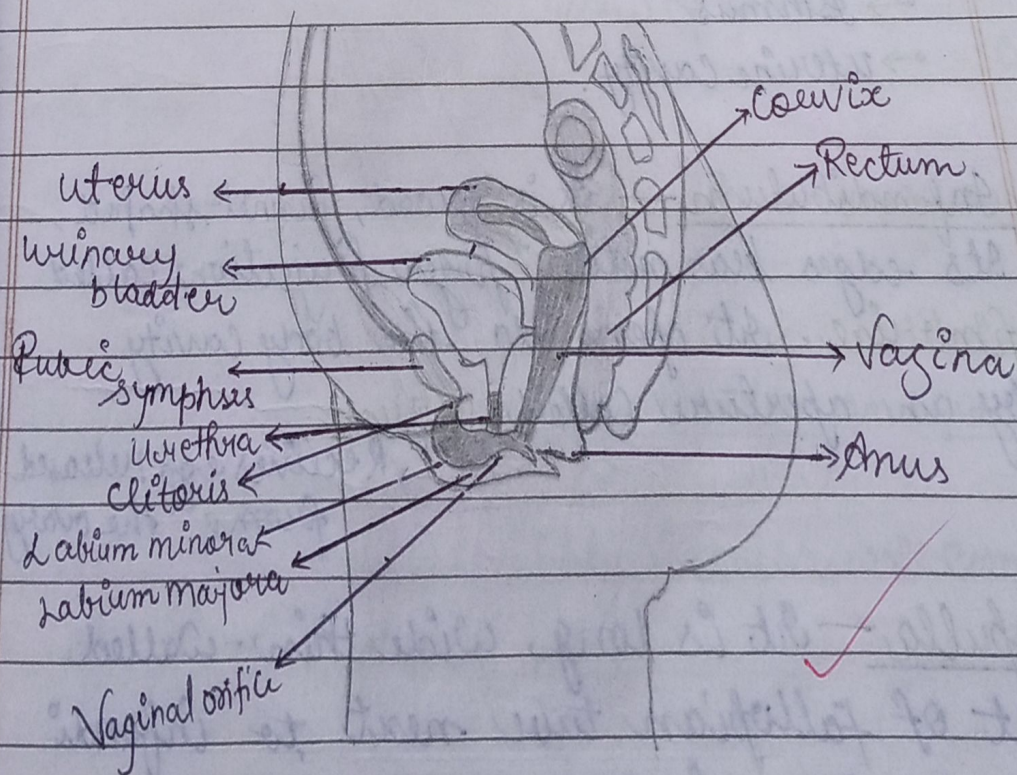


Fig- Female pelvis showing Reproductive System

SECONDARY SEX ORGANS

i) Accessory Ducts

Following parts constitute the accessory ducts.

(a) Oviducts (Fallopian tubes)

- Two small tubes of 10-12 cm in length, lying on either sides of uterus near the kidney.
- Tube carry egg from ovary to uterus & provide appropriate environment for its fertilisation.
- Fallopian tubes show four regions,
 - → Infundibulum
 - → Ampulla
 - → Isthmus
 - → uterine cavity.
- Infundibulum — It is broad, funnel-shaped, its edges bear motile, finger projections called fimbriae. It opens into the body cavity by an aperture called ostium.
 - ↳ Receives egg released from the ovary
- Ampulla — It is long, wide thin-walled part of fallopian tube next to infundibulum where fertilisation take place.

- Isthmus - It is a short narrow part that follows ampulla.
- uterine part - Pass through the uterine wall and communicates with the uterine cavity.

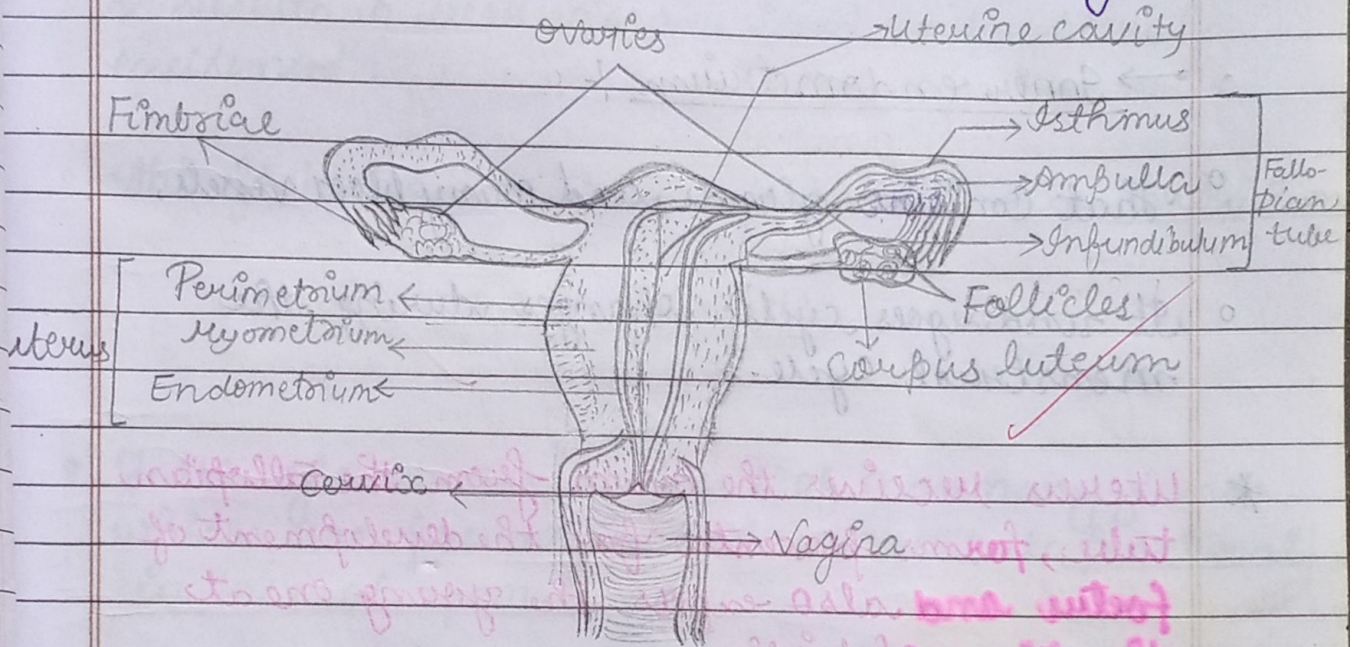


Fig- Sectional view of female Reproductive System

(b) uterus (womb)

- It is about 7.5 cm long, 5 cm wide like an inverted pear in shape.
- It lies between the urinary bladder and rectum.
- Uterus has a thick, highly vascular wall composed of three layers of tissue.
 - outer perimetrium :- A thin covering of uterus wall.

→ Middle myometrium :-

A layer of smooth muscle fibres, which contracts strongly during delivery of baby.

→ Inner endometrium :-

- That contains glands and many blood vessels.
- It undergoes cyclic changes during the menstrual cycle.

* Uterus receives the ovum from the fallopian tube, forms placenta for the development of foetus and also expels the young one at the time of birth.

(i) Cervix

- It is the narrow entrance of the uterus into the vagina.
- It is blocked by a plug of mucus.

(ii) Accessory Glands

- A pair of vestibular or Bartholin's gland

occur, on each side of the vaginal orifice

◦ They are small rounded bodies.

- These glands correspond to the Cowper's gland of male & secrete a clear, viscid fluid under sexual excitement.
- This fluid serves as a lubricant during copulation

Mammary glands

- These glands are composed of mammary glands, which are present in both sexes but functional in case of female only.
- Breasts are rounded, paired structures located over the muscles on the front wall of the thorax.
- Each breast in its middle, has a nipple surrounded by the circular, pigmented area called areola.
- Each glandular tissue of each breast divided into 15-20 mammary lobes containing clusters of alveoli which open into mammary tubules.
- Alveoli secrete milk. tubules of each lobe join to form a mammary duct.

- Just under the nipples, lactiferous ducts widen to form lactiferous sinuses. to store milk during lactation. to store milk during lactation.
- Several mammary ducts join to form a mammary ampulla.
- Ampulla is connected to lactiferous duct through which milk is sucked out.

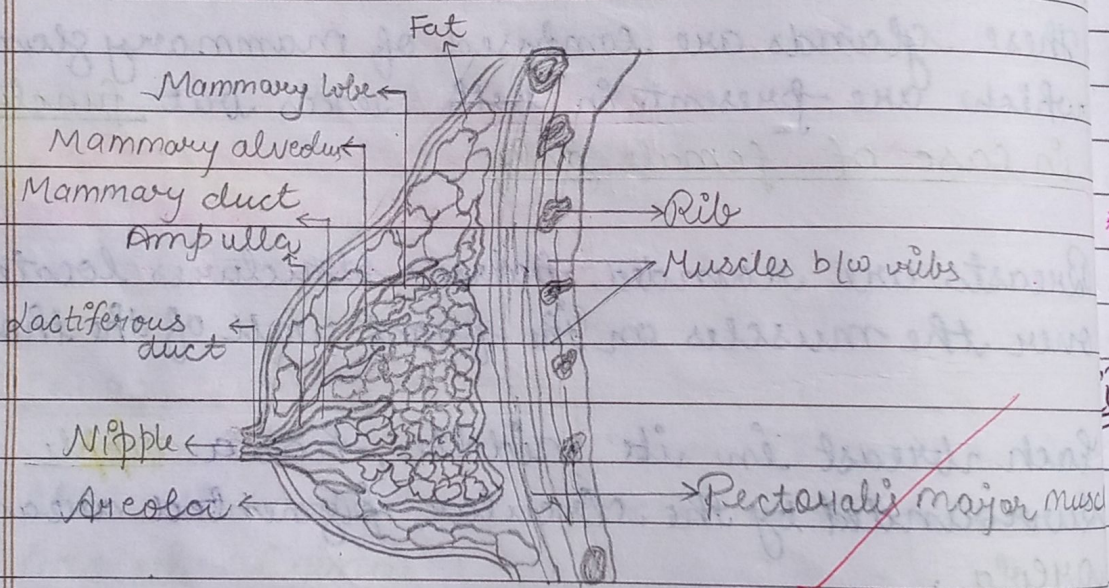


Fig- Mammary Gland

3

External Genitalia

(Vulva)

* The external genitalia of females are collectively called vulva.

It consists of the following parts.

i) Mons Pubis :-

It is the anterior most structure of vulva and is covered with skin and Pubic hair.

ii) Two longitudinal folds of skin called labia majora from the boundary of the vulva.

• It also covers two additional folds of skin called labia minora.

* Both labia majora and labia minora protect the vaginal and urethral opening beneath.

iii) Clitoris :-

It is small erectile organ, which lies at the upper junction of labia minora above the urethral opening is the homologue of glans penis of males.

iv) urethra and vagina :-

• These open by separate apertures, the urethral and vaginal orifices into the vestibule.

These two parts are homologous to the penis of males.

◦ Vagina is adapted for receiving male's penis during copulation, for allowing menstrual flow & for serving as a Birth canal during parturition.

◦ Vagina orifice normally covered by a membrane called Hymen.

* Hymen is a thin mucous membrane, which covers the vaginal opening either partly or completely.

It is often torn during the first coitus (Intercourse).

GAMETOGENESIS

✿ Process of the formation of haploid gametes from the undifferentiated diploid germ cells in the gonads, for sexual reproduction is called Gametogenesis.

Gametogenesis in human being are two types

- Spermatogenesis (In male)
- Oogenesis (In Female)

Spermatogenesis

Formation of spermatozoa (sperm) in the testes, which originate from the Primordial Germ cells (PGCs)

* Process of spermatogenesis start at Puberty

i Multiplication Phase :-

- Undifferentiated germ cells present in seminiferous tubules of the testes are called spermatogonia or sperm mother cell.
- They increase in the number by repeated mitotic divisions.
- By mitotic divisions newly formed spermatogonium possesses the same number of chromosomes.

ii Growth phase :-

- It give rise to spermatocytes
↳ sperm cell.
- Each spermatogonia is diploid and contains 46 chromosomes.

iii Maturation Phase or formation of spermatids

- Some of the spermatogonia called Primary spermatocytes undergo meiosis periodically.
- Primary spermatocyte undergo first meiotic division & produce secondary spermatocyte (23 chromosomes) which further undergo secondary meiotic division to produce spermatids.

- spermatid transformed into spermatozoa by the process called spermiogenesis.

iv Differentiation phase :-

- During spermatogenesis, the germ cell closely associated with Sertoli cell, which provide support, protection & nourishment to the developing spermatozoa (Sperms)
- After spermiogenesis sperm heads are embedded in Sertoli cell. And finally released from seminiferous tubules by the process of spermination.

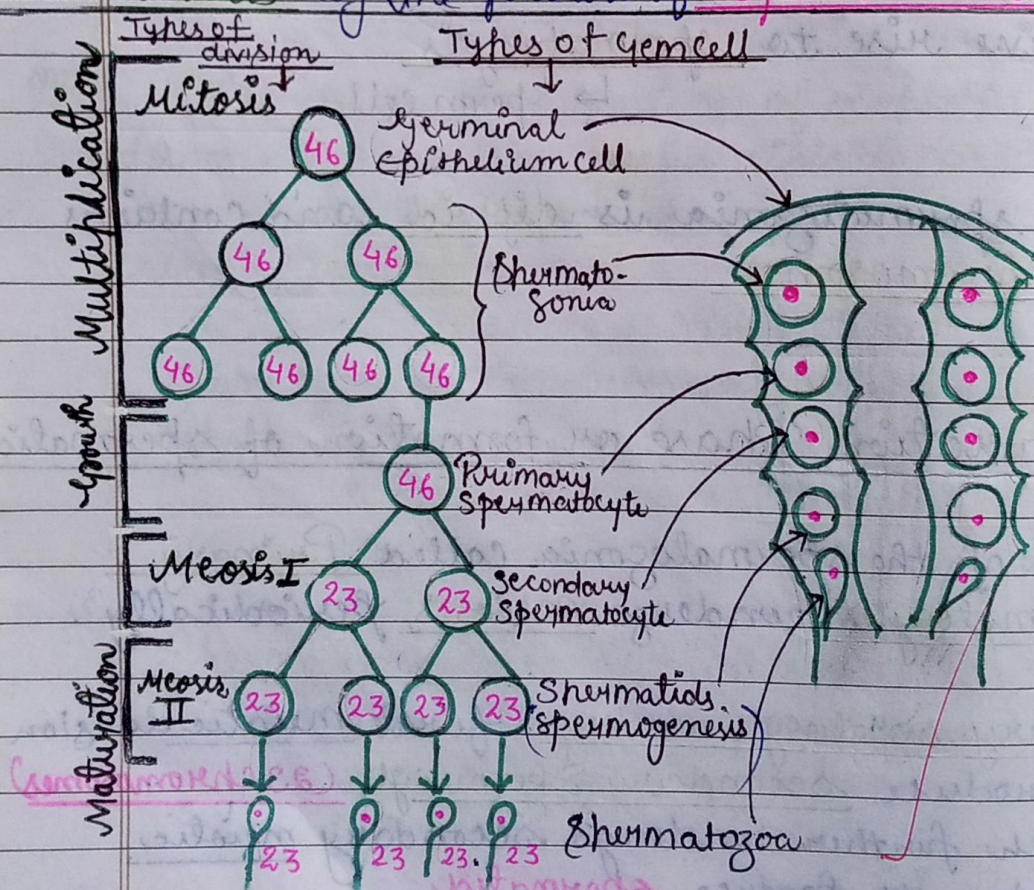


Fig- To show that stage or phase in Spermatogenesis.

HORMONES ESSENTIAL FOR SPERMATOGENESIS

1. Spermatogenesis is initiated due to increase in secretion of Gonadotrophin Releasing Hormone (GnRH)
2. Increased level of GnRH acts on the anterior Pituitary and stimulates the secretion of two Gonadotrophins
 - Luteinising Hormone (LH)
 - Follicle Stimulating Hormone (FSH)
3. LH acts on Leydig cells stimulating the synthesis and secretion of Androgens.
4. FSH acts on Sertoli cells and stimulates the secretion of some factors which help in Spermiogenesis.

STRUCTURE OF A SPERM (spermatozoa)

A mature spermatozoa or sperm cell is a microscopic. [tadpole-shaped structure of about 2-5 μm in diameter & 60 μm long.]

Plasma membrane encloses the entire sperm.

It consists of a head, neck, middle piece & a tail.

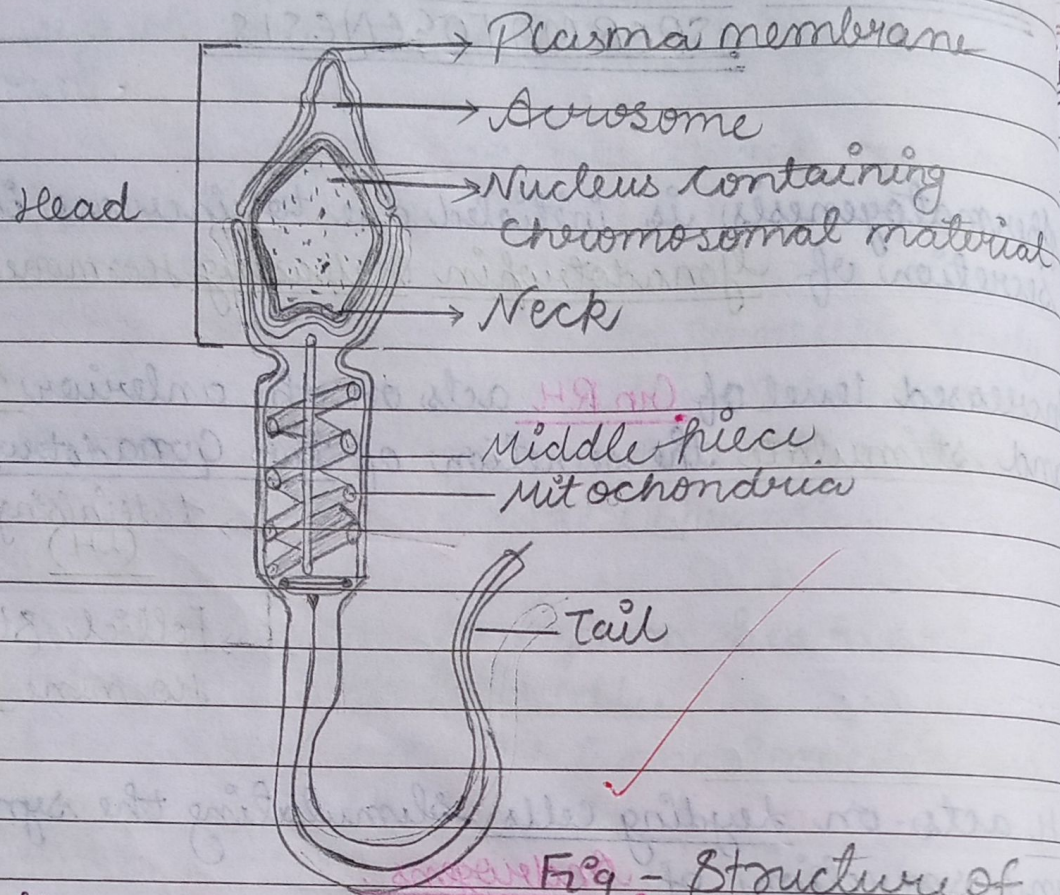


Fig - Structure of a sperm

i Head :-

- It is flat, oval and composed of a large haploid nucleus and a small anterior cap-like structure, called acrosome.
- Lies at tip of nucleus & form from Golgi complex.
- It contains hydrolytic enzymes and used to contact & penetrate egg during fertilisation.

ii Neck :-

- It is short & contains two Centrioles, one lying behind the other at right angles.

→ Proximal Centriole
 → Distal Centriole
- Proximal Centriole plays a role in first cleavage of Zygote.
- Distal Centriole gives rise the axial filament of the sperm.

iii Middle piece :-

- It is cylindrical & known as the power house of the sperm.
- It have many mitochondria to produce energy for the movement of tail & facilitates sperm motility essential for fertilisation.

iv Tail :-

- It is a very long, slender & tapering structure formed of cytoplasm.
- fine thread called axial filament arises from posterior centriole & transverse the middle piece & the tail.

✓ amp

- The spermatozoa swim by vibrating their tail in a fluid medium in search of ova.

If a sperm fails to contact an ovum within a specific period, it exhausts its energy & dies.

NOTE

Human male ejaculates about 200-300 million sperms during a coitus.

For normal fertility, about 60% of them must have normal shape & size,

while at least 40% of them must show vigorous motility.

O O G E N E S I S



It is the process of formation of a mature female gamete. The production of egg in females begins before birth but it completed only after fertilisation.

i Multiplication Phase :-

- Cells of germinal epithelium undergo mitotic division producing undifferentiated germ cell called oogonia or egg mother cell within each

fetal ovary.

- These cells start division & enter Prophase-I of meiotic division and get temporarily arrested at this stage. Known as Primary oocytes.

ii Growth Phase:-

- Primary oocyte then gets surrounded by a single layer of granulosa cells and is called Primary follicle.
- The primary follicle gets surrounded by more layers of granulosa cells and a new theca to form Secondary follicles.

NOTE - About 2 Million of these follicles exist in female before birth. A large number of these follicles degenerate during the phase from birth to puberty.

At puberty only 60,000-80,000 primary follicles are left in each ovary.

iii Maturation Phase:-

- In this phase, the secondary follicles soon transform into tertiary follicles.
- These are characterised by a fluid cavity called antrum.

- Theca layer is organised into an inner theca and an outer theca externa.

- Primary oocyte within tertiary ~~nuclei~~ follicle grows in size.

- Fully grown primary oocyte completes its first meiotic division ~~divi~~ producing two daughter nuclei and larger haploid cell called Secondary oocyte and tiny one is called first polar body.

- * Secondary oocyte retains bulk of nutrient rich cytoplasm of primary oocyte.

- Tertiary follicle further changes into a mature follicle or graafian follicle.

- The secondary oocyte forms a new membrane called zona pellucida around it & starts its second meiotic division but remains suspended in metaphase-II till the sperms enter it.

- Graafian follicle, ruptures to release the secondary oocyte from the ovary.

- The release of the secondary oocyte from the ovary is called Ovulation.

Multiplication Phase

Growth Phase

Maturation Phase

◦ 1st

◦ 2nd

◦ 3rd

◦ 4th

◦ 5th

◦ 6th

◦ 7th

◦ 8th

◦ 9th

◦ 10th

◦ 11th

◦ 12th

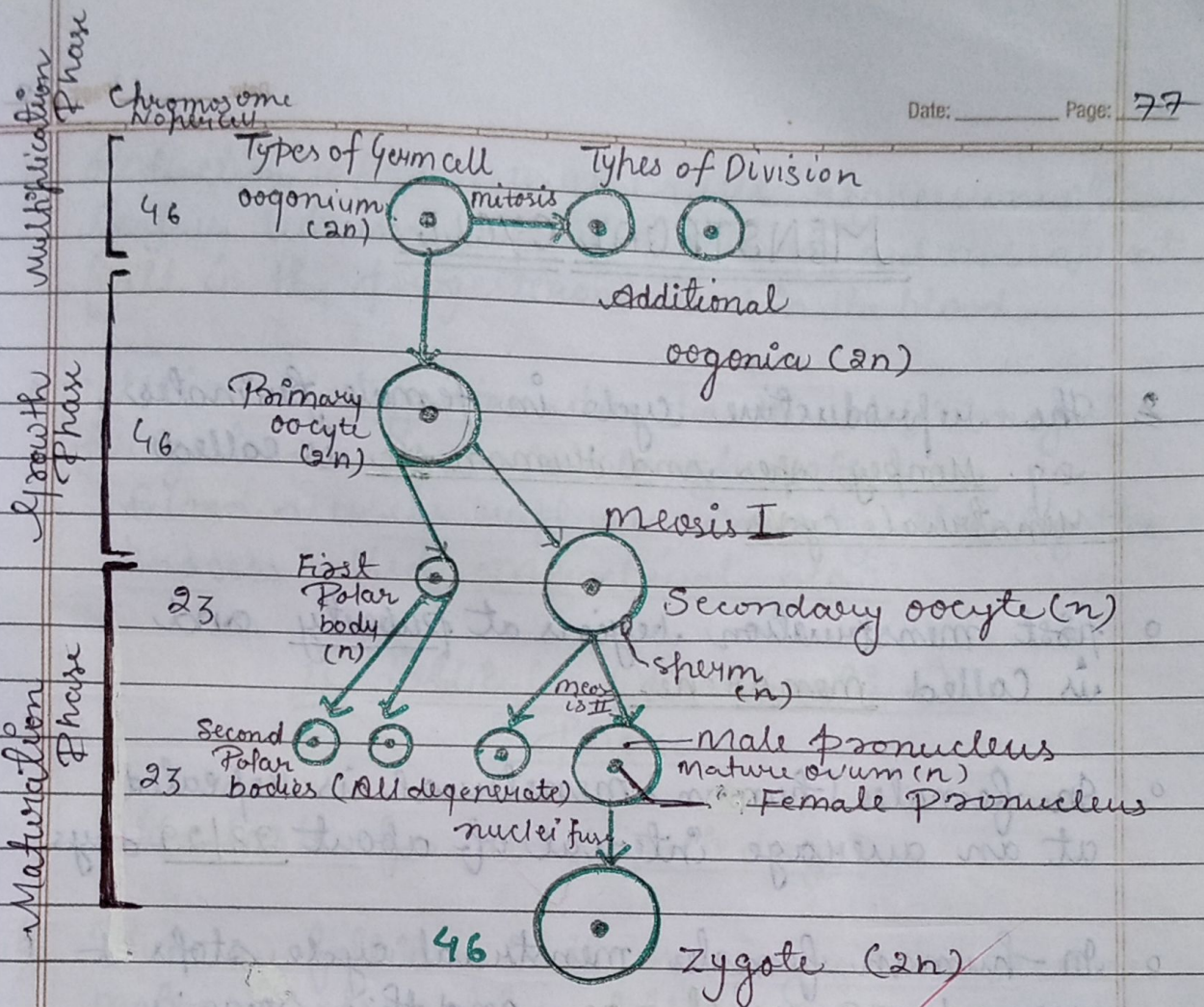


Fig- To show that stage in oogenesis

OVUM

- The ovum is a rounded, non-motile cell.
- In human, the ovum is yolk free i.e. alecithal.
- It has abundant cytoplasm called ooplasm having a large nucleus as germinal vesicle with a prominent nucleolus at the center.

MENSTRUAL CYCLE

- The reproductive cycle in female primates, e.g. Monkey, apes and human etc is called menstrual cycle.
- first menstruation begins at puberty and is called menarche.
- In females (human) menstrual is repeated at an average interval of about 28/29 days.
- In human females menstrual cycle stops at around 50 yrs of age and this stage is called menopause.
- The menstrual cycle consist of four phase.

i Menstrual Phase

Cycle starts with menstrual phase it lasts for about 3-5 days.

It involves the following events.

- a) If fertilisation does not occur, the unfertilized egg undergoes autolysis.

- b) Reduction of LH level causes regression of corpus luteum by autolysis & a consequent fall in the progesterone level in the blood.
- c) uterine lining dies due to the deficiency of progesterone and is sloughed off. Blood vessels rupture, causing bleeding the process called menstrual flow.

ii. Follicular (Proliferative) Phase

It lasts for about 14th days.

- a) Primary follicle in the ovary grow to become mature Graafian follicle.
- b) endometrium of uterus regenerates through Proliferation.
- c) changes in ovary & uterus are induced by changes in the levels of Pituitary and ovarian hormones.
- d) The secretion of Gonadotropins (LH and FSH) increases during follicular phase & stimulates follicular development as well as secretion of oestrogens by the growing follicle.

iii Ovulatory Phase

- o Both LH and FSH attain a peak level in the middle of cycle (about 14th day)
- o Rapid secretion of LH leading to its maximum level during the mid-cycle is called L.H. Surge.
- o It induces rupture of Graafian follicle and thereby the release of ovum i.e. Ovulation.
- o The Ovulation (Ovulatory Phase) is followed by the Luteal Phase.

iv Luteal Phase

This stage lasts about 10th day.

- a) Remaining part of Graafian follicle transform as the corpus luteum.
- b) Peak of LH, together with prolactin hormone from anterior pituitary stimulates the follicular cells of the empty Graafian follicle to form corpus luteum.
- c) Corpus luteum secretes large amount of Progesterone essential to maintain endometrium.

d) endometrium is necessary for implantation of the fertilised ovum and other events of Pregnancy.

In the absence of fertilisation, the corpus luteum degenerates.

e) This causes disintegration of endometrium leading to the menstruation and a new cycle starts

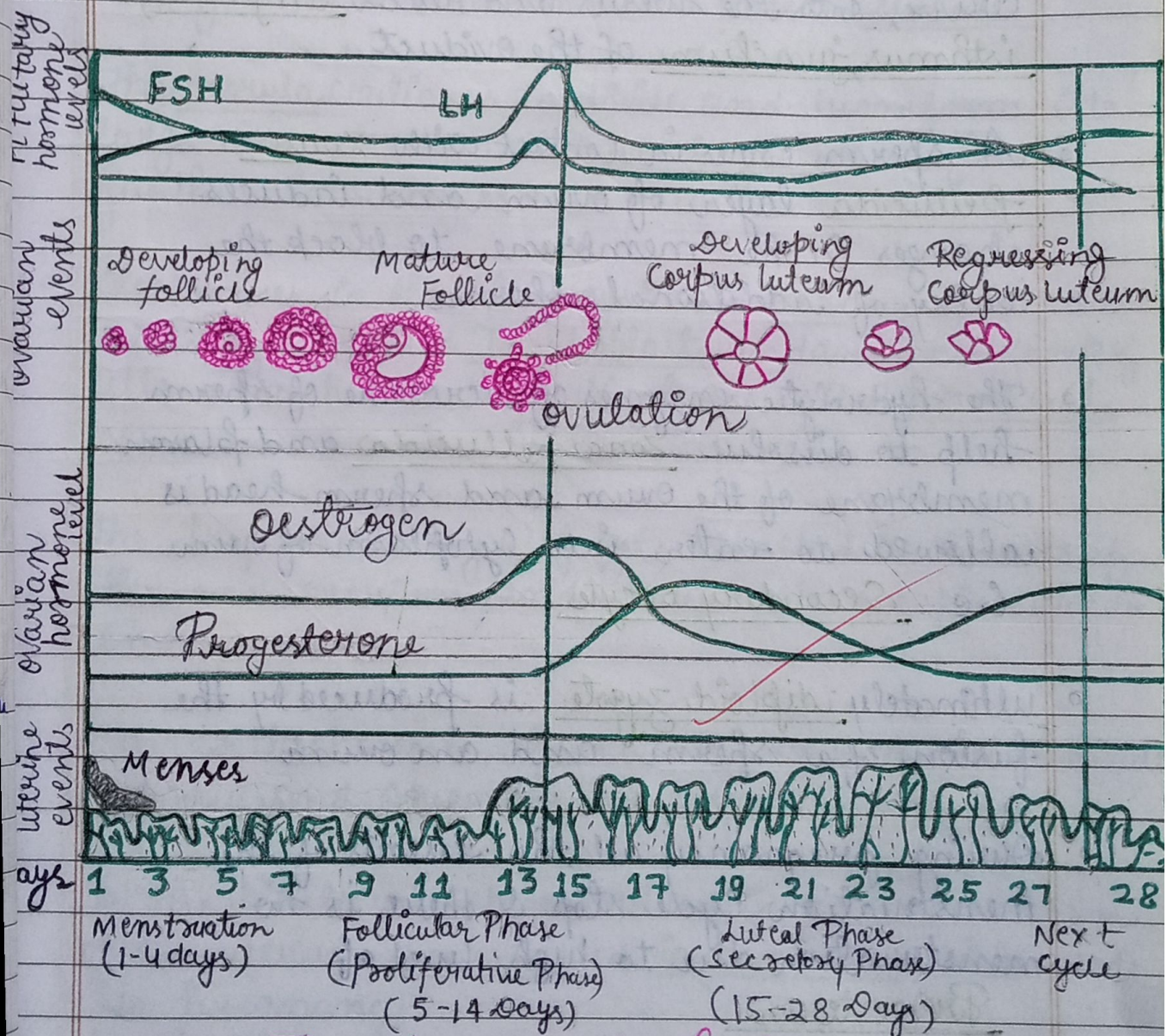


Fig - To show that various events during Menstrual cycle.

FERTILISATION

- The process of fusion of sperm with ovum is called Fertilization.
- During Coitus, semen is released by penis into Vagina i.e. called Insemination.
- The motile sperms swim rapidly through the Cervix, into the uterus and reach ampullary-isthmus junction of the oviduct.
- A sperm comes in contact with Zona pellucida layer of ovum and induces changes in the membrane to block the entry of additional sperms.
- The hydrolytic enzymes of acrosome of sperm help to dissolve Zona pellucida and plasma membrane of the ovum and sperm head is allowed to enter into cytoplasm of ovum i.e. Secondary oocyte.
- Ultimately diploid zygote is produced by the fusion of a sperm and an ovum.
- During pregnancy all the events of the menstruation cycle stop & there is no menstruation due to high level of Progesterone.

Fig - To show that various events during menstruation cycle.

IMPLANTATION

- Zygote divides rapidly by mitotic division as it moves through isthmus of oviduct towards uterus. This is called cleavage.
- As a result 2, 4, 8 and 16 daughter cells are produced which are termed as blastomeres.
- Embryo with 8-16 blastomeres is called a Morula.
- The morula continues to divide and transform into large mass of cells called blastocyst which passes further into uterus.
- Blastomeres in the blastocyst are arranged into an outer layer called Trophoblast and an inner group of cells attached to trophoblast are called inner cell mass.
- The trophoblast layer gets attached to the cells of the endometrium and inner cell mass gives rise to embryo.
- After attachment, the cells of endometrium divide rapidly and cover the blastocyst.
- So, the blastocyst gets embedded in the endometrium of the uterus. This is called implantation which leads to pregnancy.

EMBRYONIC DEVELOPMENT

- The cells of the trophoblastic differentiate into an inner layer and outer layer.
- The outer layer is called Chorion and forms the Chorionic villi, which are finger like projections that grow into the endometrium.
- Placenta is formed in 8-9 days.

FUNCTION OF PLACENTA

- Provide nutrient and oxygen to developing embryo.
- Acts as an endocrine tissue and produces several hormones like human ~~chorionic~~ gonadotrophin (HCG), human placental lactogen (HPL), Estrogen, Progesterone that are essential to maintain Pregnancy.
- An umbilical Cord connects placenta with the embryo that helps in the transport of substances to and from the embryo.
- The inner cell mass of blastocyst develops into three layers.
- * Outer layer called ectoderm.

- * Inner layer called endoderm
- * Middle layer called Mesoderm.

- Inner cell mass contains certain cells called stem cells that have the potency to give rise to all the tissue and organs.
- After the one month of pregnancy, the embryo's heart is formed.
- By the end of second month of pregnancy, the foetus develops limbs and digits.
- Appearance of hair on the head and foetus movement is observed during fifth months.
- After six months, the body is covered with fine hairs, eyelids separate and eyelashes are also formed.
- By the end of nine months of pregnancy the foetus is completely developed & the foetus is ready for its delivery.

PARTURITION

- The average duration of human Pregnancy is about 9 months which is called the Gestation Period.
- The act of expelling the full term foetus from the

Date: _____ Page: _____
mother's uterus at the end of gestation period is called Parturition.

- Parturition signals originate from the fully developed foetus and the placenta which induce mild uterine contraction called foetal ejection reflex.
- This helps in the secretion of oxytocin from the maternal Pituitary.
- Oxytocin induces stronger uterine muscles contraction which lead to expulsion of the baby from the uterus through the birth canal.

LACTATION

- Mammary glands of female undergo differentiation and start producing milk at the end of pregnancy. This is called Lactation.
- This helps the mother in feeding the newborn.
- The milk that comes out of mammary gland during initial days of lactation is called Colostrum. (nutrient & antibody)
- Thus, breast feeding is recommended by doctors for bringing up a healthy baby.